SR-60 TRUCK LANE FEASIBILITY STUDY

FINAL REPORT

FEBRUARY, 2001

PREPARED FOR

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

PREPARED BY

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RECOMMENDATIONS

In light of our conclusions regarding feasibility, we make these recommendations:

1. SCAG should use the information produced by this Feasibility Study in the **update of the Regional Transportation Plan with respect to the role of dedicated truck lanes** in the overall transportation picture.
2. SCAG should **evaluate the effect of truck-lane user charges** on the economics of truck transportation in the region and the state, considering such factors as productivity changes and the potential for changes in the cost of fuel (e.g., under nationwide uniformity of diesel formulation).
3. **Caltrans, Los Angeles County Metropolitan Transportation Authority and San Bernardino Associated Governments** should decide the role of dedicated truck lanes in the transportation system and when they would consider taking the next step toward truck lanes in the SR-60 corridor.
4. **The next step in the SR-60 corridor** should be to prepare a major multi-modal corridor analysis (as in the I-710 and I-15 corridors) with engineering and environmental documentation that can be used for Project Study Reports for high-priority projects; that analysis should include full consideration of all potential alternative alignments, freight management techniques and capacity improvements for mixed-flow traffic as well as trucks.

The Regional Council approved the recommendations of the SR-60 Truck Lane Feasibility Study on February 1, 2001 as summarized above.

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Executive Summary

CHAPTER 1. EXECUTIVE SUMMARY

The current Regional Transportation Plan for the SCAG region identifies dedicated truck lanes as means to more efficiently keep goods movement flowing smoothly, improve overall mobility along the freeway, and improve traffic safety and air quality issues. The For evaluating the feasibility of dedicated truck lanes, the RTP places high priority on the SR-60 corridor. SCAG's Truck Lane Task Force has been asked to assess the feasibility of dedicated truck lanes. The work in this SR-60 Truck Lane Feasibility Study has focused on such factors as design alternatives, financial impact, highway operations, safety considerations, environmental impacts and regional benefits.

The consultant team conducting the SR-60 Truck Lane Feasibility Study has concluded that dedicated truck lanes are feasible under certain conditions. This chapter describes those conditions and the feasibility evaluation based on several criteria including accessibility and mobility, cost-effectiveness, safety impacts, operational characteristics, regulatory concerns, regional benefits and environmental sensitivity. This Final Report consists of the Task Reports we have presented to the Task Force documenting the results of the evaluation of conceptual alternative improvements.

TECHNICAL FEASIBILITY

Truck-volume forecasts for the year 2020 made by SCAG's Heavy Duty Truck Model indicate that a four-lane (two in each direction) facility would be required to accommodate the truck demand. The following table gives details from SCAG's Model (1994 is the Model's "base year"); the capacity of a truck lane is 800 – 1,000 trucks per hour.

	Truck Volume per Hour per Direction		
Location	**1994**	**2020**	**Growth 1994-2020**
West End	1,890	2,850	960
East of I-605	1,360	2,200	840
SR-57 Junction	1,474	2,970	1,500
East of SR-71 Junction	1,180	2,310	1,130
East End	2,200	4,000	1,800

Consequently, the consultant reports analyze two final conceptual alternatives: adding four lanes at grade and adding four lanes above the freeway grade.

The at-grade widening alternative would require acquisition of new right-of-way at various locations along the corridor. This would affect residences, businesses and commercial buildings as well as schools, parks and other environmentally sensitive areas adjacent to the freeway. Impacts of elevated segments would be of a lesser degree. **All of these impacts would require comprehensive environmental studies before a project can be approved for implementation.** Those studies should more fully evaluate other alternatives - noted during the community outreach just completed - including all potential alternative alignments.

A recommended alternative was developed combining elements of both analyzed alternatives to form a hybrid solution. The recommended alternative consists mostly of adding four truck lanes at grade with aerial sections at the western end of the corridor (from I-710 to Vail Street) and east of I-605 (from I-605 to Fullerton Road). It is shown on the accompanying map. Photos attached show what each section would look like.

Aerial portions should be kept to a minimum due to safety and operational considerations regarding trucks traveling on an elevated structure as well as due to higher construction costs. In the two segments of the corridor where aerial section is recommended, we believe elevating the truck lanes will avoid the extreme amount of property acquisitions necessary in those locations to provide the required right-of-way at freeway grade (many of these properties are sensitive properties such as schools). Consequently, we believe further work should consider the dedicated truck-lane facility at freeway grade except for those two segments. That work should also include design and operational studies that consider having the HOV or mixed-flow lanes on the elevated segments, keeping all trucks at freeway grade.

Conclusion: If the option is pursued to add an elevated structure in designated portions of the corridor, truck lanes are feasible from the perspective of engineering and environmental considerations.

COMMUNITY FEASIBILITY

Community outreach for this feasibility study has reached this **conclusion: If all potential alternative alignments are given due consideration in further project development, the community along the corridor is likely to consider truck lanes to be feasible.**

FINANCIAL FEASIBILITY

Our analysis shows that at most $1.2 billion of $4.3 billion in corridor construction costs could be financed by leveraging the net revenue from truck-lane user fees. With a large gap between user-fee revenue and construction cost, it seems unlikely that other private sources of funding could be found. Therefore, **project construction will require an infusion of capital from local, state and federal sources.**

This public investment may be justified because providing dedicated truck lanes would reduce the requirement for mixed-flow lanes on the SR-60 freeway in 2020. The accompanying bar chart is the product of comparing four forecasts of the number of mixed-flow traffic lanes. The first bar shows the number of additional mixed-flow lanes which the SCAG Model forecasts would be necessary in the SR-60 corridor to maintain the <u>current peak-period level of service</u>; that bar is labeled "*w/o Truck Lanes (per SCAG*

Model)." The second bar—labeled '*w/ Four Truck Lanes (per SCAG Model)*'—allows us to see the impact of introducing four truck lanes (two in each direction) on the number of mixed-flow lanes forecasted to be required. Inspecting the difference between the first two bars reveals that in most areas one fewer mixed-flow lane per direction would be needed but in some areas that number is three fewer mixed-flow lanes. The third bar shows the difference made by the introduction of user fees on the truck lanes. In all but two areas of the corridor, the reduction in additional mixed-flow lanes is eliminated by charging trucks to use the dedicated lanes.

The fourth bar on the chart is taken from the "Transportation Concept Report" (TCR) for SR-60 being drafted by Caltrans District 7, which evaluates the "ultimate" needs of the corridor as well as concepts for adding lanes to the freeway within the next 20 years. For comparison purposes only, we have shown the bar labeled "*Caltrans 2020 Transportation Concept Report – Maximum*" It indicates how many additional mixed-flow lanes (not taking truck lanes into account) Caltrans believes would be needed to attain a <u>free-flowing</u> SR-60 freeway.

While it is not considered feasible by any agency to add to the SR-60 freeway as many lanes as shown on the barchart, the comparison is useful to illustrate the contribution truck lanes could make to meeting the need for more capacity in the corridor.

Due to the large magnitude--both geographically and financially--of the SR-60 truck lanes, a detailed, incremental implementation strategy will need to be developed once a final determination is made of the improvements required. Our consultant reports have presented some preliminary implementation concepts to be refined in further work in the corridor. That future work should investigate various cost-recovery options in more depth than we have been assigned to do in this feasibility study. Such options might include different approaches to user fees and how they would affect demand for truck lanes plus a separated toll road in the corridor that is open to all vehicles with a fee structure for trucks and passenger vehicles that can be adjusted to reflect congestion levels.

Conclusion: If public recognition of the benefits of SR-60-corridor truck lanes to the overall transportation picture results in support for programming of public funding (federal, state and regional), truck lanes are financially feasible.

In light of our conclusions regarding feasibility, we make these recommendations:

1. SCAG should use the information produced by this Feasibility Study in the **update of the Regional Transportation Plan with respect to the role of dedicated truck lanes** in the overall transportation picture.
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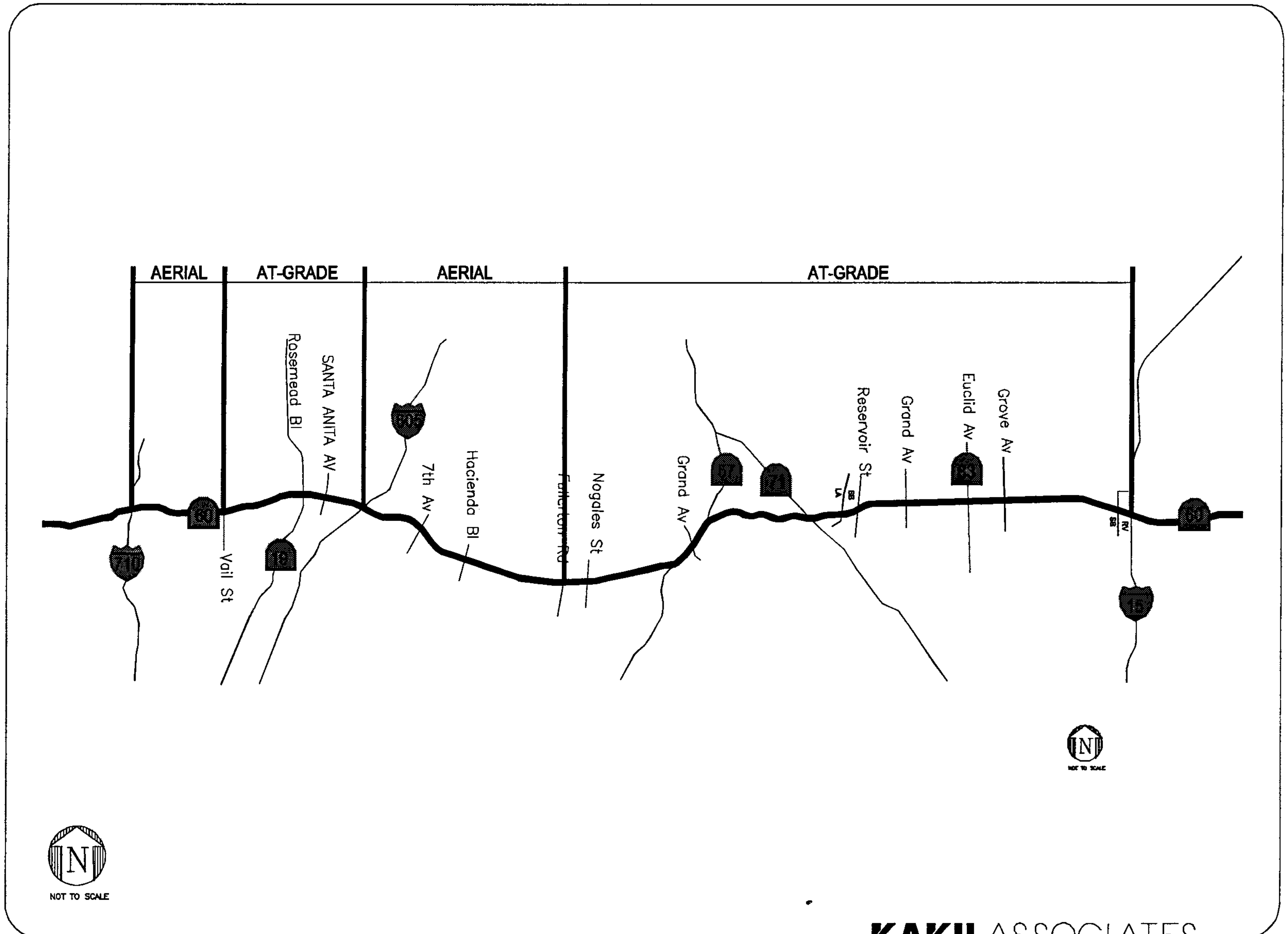

Figure 1.1 RECOMMENDED ALTERNATIVE

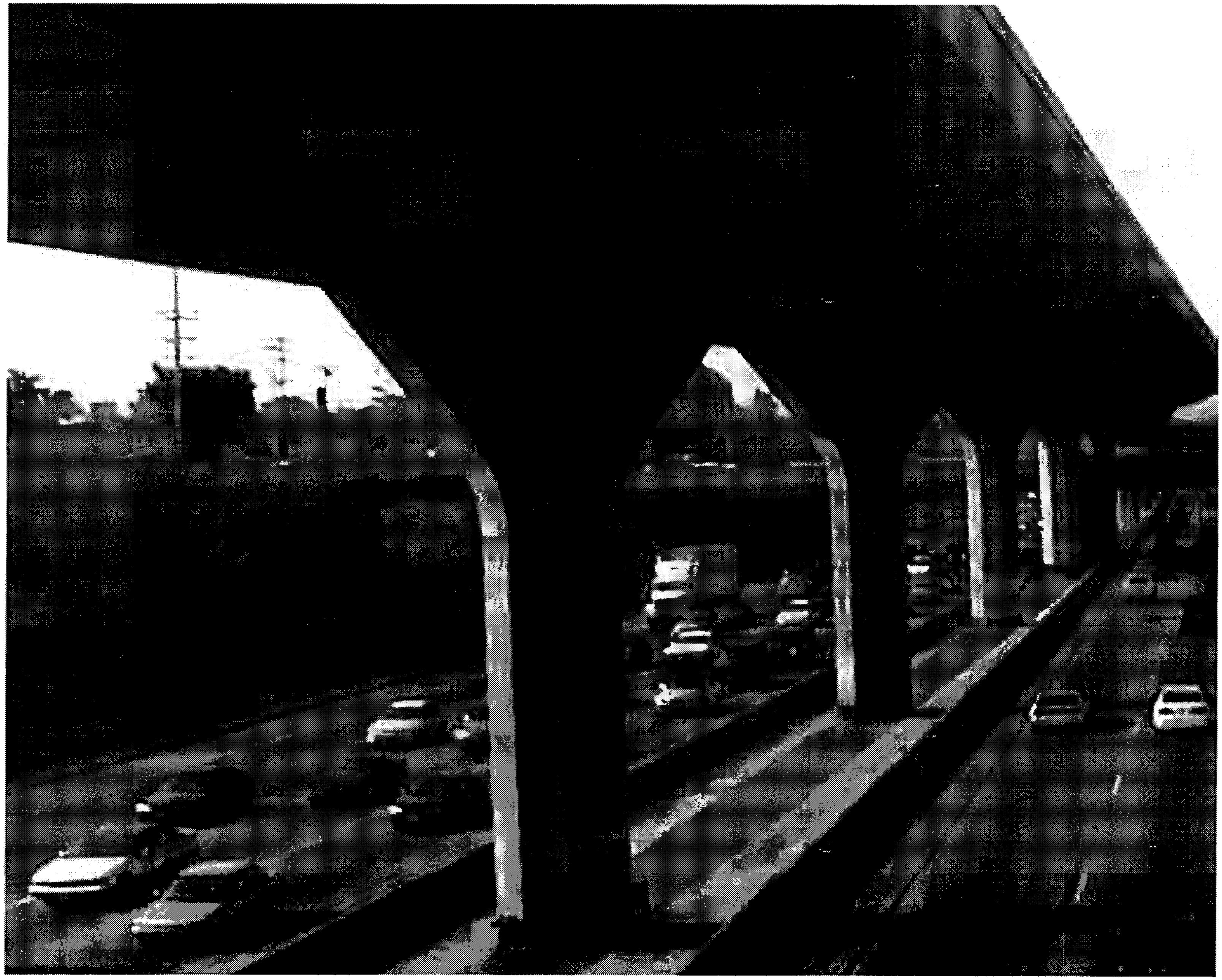

Figure 1.2 I-710 to Vail and I-605 to Fullerton

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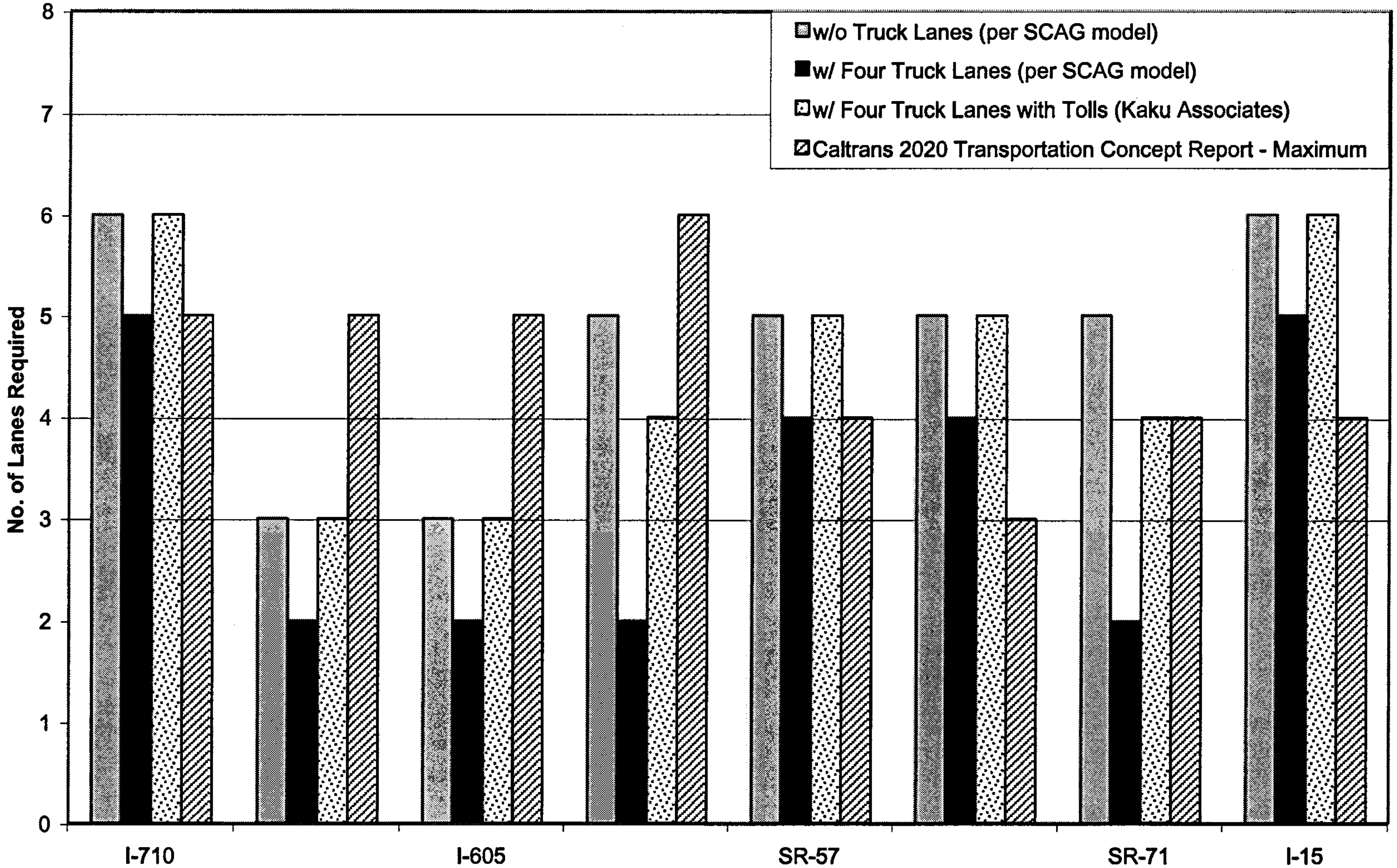
Figure 1.3 Other Sections of SR-60

Figure 1.4

Number of Additional SR-60 Mixed-Flow Lanes per Direction Required in 2020



Chapter 2
Background Information

SUMMARY

The literature review indicates that many jurisdictions are concerned with increasing truck traffic and its effect on operations and safety. Many types of strategies have been examined for feasibility including exclusive facilities, truck lanes, and lane restrictions. Lane restrictions and exclusive truck lanes that are non-barrier separated from the main lanes are similar. Feasibility studies regarding restrictions and exclusive lanes found that exclusive facilities were most plausible for congested highways where three factors exist. The three factors that warrant a barrier separated facility are truck volumes exceed 30 percent of the vehicle mix, peak hour volumes exceed 1,800 vehicles per lane-hour, and off-peak volumes exceed 1,200 vehicles per lane-hour *(5)*.

The review also found that very few truly exclusive facilities exist. Most facilities restrict trucks and/or buses to specified lanes, but allow other vehicles to use any lane. In almost every instance where restrictions or truck lanes were implemented there were negligible changes in operations and safety. However, it should be noted that no comprehensive before and after studies have been conducted regarding the implementation of truck lanes or truck restrictions. Consequently, there is little documentation that could be used for a true cost/benefit analysis of the strategy.

Theoretically, truck facilities could have positive impacts on noise and air pollution, fuel consumption, and other environmental issues. Creating and maintaining an uninterrupted flow condition for diesel-powered trucks will result in a reduction of emissions and fuel consumption, when compared to congested stop-and-go conditions. However, the creation of a truck facility may also shift truck traffic from more congested parallel roadways, therby shifting the environmental impacts. There may also be increases in non-truck traffic on automobile lanes due to latent demand.

Generally, public opinion is favorable to truck restrictions and unfavorable to exclusive truck facilities or special truck lanes. Public acceptance to any strategy is paramount to successful implementation, therefore it is important to correctly market any strategy prior to implementation.

INTRODUCTION

The passage of the Surface Transportation Assistance Act (STAA) in 1982 and the Tandem Truck Safety Act (TTSA) in 1984 established a national network of highways as a designated large truck network. These acts, as well as the subsequent deregulation of trucking industry and the passage of the North American Free Trade Agreement (NAFTA), have all greatly impacted the number of trucks on the nation's roadways. Large trucks are the principal means for moving goods in urban areas, and the number of trucks in the traffic stream is anticipated to increase with the full implementation of NAFTA. The role of large trucks is vital to the nation's economic well being; however, the public perceives that the presence of large trucks has a significant impact on road safety.

At the same time that trucks were increasing in size, power, and numbers, passenger cars were decreasing in size and power. The differential in size between trucks and passenger create an intimidating psychological barrier, if not an actual barrier. Trucks have slower braking and acceleration rates than passenger cars, which increases frustration to drivers in congested situations. Additionally the lack of maneuverability of trucks relative to passenger cars contributes to crashes *(1)*. Due to the large size and weight of trucks, truck crashes generally result in more severe injuries than crashes that do not involve trucks. Truck crashes also receive greater publicity.

The issue of increasing truck traffic is of vital concern to both traffic managers and the general public. Highway traffic operations are the "yardstick" by which the user measures the quality of the facility. The characteristics that matter most to the driver are speed of travel, safety, comfort, and convenience. As a result of increasing demand on highways, a variety of strategies or countermeasures for trucks have been implemented in an attempt to mitigate the effects of increasing truck traffic. Some of the most common strategies considered are lane restrictions, time of day restrictions, peak period bans, route restrictions, and exclusive truck facilities.

FEASIBILITY STUDIES OF LANE RESTRICTIONS AND EXCLUSIVE FACILITIES

Two of these strategies, lane restrictions and exclusive truck facilities, are similar in intent. Both attempt to decrease the effects of trucks on safety and reduce conflicts by the physical separation of truck traffic from passenger car traffic. Lane restrictions separate traffic by designating specific usage of lanes by vehicle type, while exclusive truck facilities designate facility usage by vehicle type.

Mason et al. *(2)* described seven types of truck lane configurations in a study performed in 1985. All of these lanes could be constructed within an existing right-of way. The first truck lane, designated as M-1A, is a minimum median truck lane. Trucks use 12 foot inside lanes that have a 5-foot inside shoulder, while other vehicles utilize the outside lanes. Lanes for trucks and cars are not barrier separated. The second truck lane, designated M-1B, is a desirable median truck lane. The configuration is the same as for M-1A truck lane, with the exception of 10 to 12-foot inside shoulders. The third truck lane, known as M-2, is an outside truck lane. Trucks travel on 12 foot outside lanes that have 12-foot shoulders. These lanes are not barrier separated from the inside car lanes. The fourth type of configuration is the M-3 truck lane, which is a four lane truck facility. Trucks travel on two 12 foot inside lanes that have 5 foot inside shoulders. The trucks are not barrier separated from the outside car lanes. The fifth type of facility is the M-4, which is an inside 12-foot truck lane that has a 10-foot inside shoulder and a depressed median. The truck lane is not barrier separated from the car lanes. The sixth type of configuration is the M-5 protected truck lane with a passing lane. Trucks travel on 12-foot lanes that have a 4-foot inside shoulder and a 10-foot outside shoulder. This facility is barrier separated from the outside car lanes. The final configuration is the M-6 elevated truck lanes. Trucks travel on two 12-foot lanes that have a 4-foot inside (left) shoulder and a 10-foot outside (right) shoulder. This facility is elevated above the passenger car lanes *(2)*.

The authors then developed and applied a moving analysis computer program to determine the feasibility for each of the seven truck facilities. The program utilized volume-to-capacity ratios and effective median width as its two major parameters. The authors cited advantages and disadvantages for each of the seven configurations *(2)*.

Feasibility Study for Houston-Beaumont Corridor

In 1986, a research study *(3, 4)* by the Texas Transportation Institute (TTI) examined the feasibility of an exclusive truck facility for a 75-mile segment of I-10 between Houston and Beaumont. The options considered in the study included: the construction of an exclusive truck facility within the existing I-10 right-of-way; construction of an exclusive truck facility immediately adjacent to I-10 outside of the existing right-of-way; or construction of an exclusive facility on, or immediately adjacent to, an existing roadway that parallels I-10 (U.S. 90).

Lamkin and McCasland *(4)* examined the existing traffic conditions, geometric design, land development and usage, truck services and usage, and pavement structures for the exclusive facility alternatives. Benefits and costs of an exclusive truck facility that were considered during the evaluation included: safety, improved capacity and operations, time travel savings, pavement life, construction costs, right-of-way acquisition, conversion costs, and impact to local environment. The authors concluded that existing and future trends in traffic volumes did not warrant an exclusive facility along the I-10 corridor. Specific conclusions in the analysis included the following:

- The conversion of a non-freeway facility which passes through smaller communities, such as the parallel US 90, to an exclusive truck facility is not feasible. The impact to nonusers could not be offset by the benefits to the users, and the additional travel distance required by the facility would require high speeds to gain travel time savings.
- Only short sections (10 to 12 miles) of existing I-10 right-of-way could geometrically accommodate exclusive facilities without the construction of major structures, such as bridges and flyovers.
- Locations for an exclusive facility outside of the right-of-way presented problems in right-of-way acquisition, provision of truck roadside services, local traffic circulation, and freeway to exclusive facility interconnections *(4)*.

EVFS Computer Program

In a 1990 FHWA study, Janson and Rathi *(5)* examined the feasibility of designating exclusive lanes for vehicles by type. This study, which ultimately resulted in a computer program known as exclusive vehicle facilities (EVFS), evaluated exclusive lane use feasibility by utilizing the following lane use possibilities:

- Mixed vehicle lanes—lanes utilized by all vehicles,
- Light vehicle lanes—lanes utilized only by motorcycles, automobiles, pickup trucks, light vans, buses, and trucks weighing less than 10,000 pounds, and
- Heavy vehicle lanes—lanes utilized only by single unit trucks weighing more than 10,000 pounds and all combination vehicles.

The authors designed an analysis format that could evaluate the economic feasibility of exclusive lanes for specific sites on high-volume, limited access highways in both urban and rural areas. In order for a highway to be considered, three or more lanes in one direction must be available. The format of the program considered potential benefits and costs, including travel time savings, vehicle operating cost savings, reduced crash costs, travel delay savings, initial construction costs, right-of-way costs, pavement resurfacing costs, and maintenance costs. The program then calculated net present worth, benefit-cost ratio, and other facility performance measures. The design resulted in five possible options with three options employing designated lane usage or vehicle facility alternatives.

- Option 1: Do nothing,
- Option 2: Designate existing lanes for mixed, light, and heavy vehicles,
- Option 3: Add mixed vehicle lanes,
- Option 4: Add nonbarrier separated lanes and designate the usage for both new and existing lanes, and
- Option 5: Add barrier separated lanes and designate usage for both the new and existing lanes *(5)*.

Janson and Rathi found that exclusive facilities were most feasible for congested highways where three factors exist. The three factors that warrant a barrier separated facility are truck volumes exceed 30 percent of the vehicle mix, peak hour volumes exceed 1800 vehicles per lane-hour, and off-peak volumes exceed 1200 vehicles per lane-hour *(5)*.

Virginia Evaluations of EVFS

In 1996 and 1997, a series of studies *(6, 7, 8)* investigated the separation of truck traffic through the use of exclusive facilities. In May 1996, Vidunas and Hoel *(6)* evaluated the strengths and weaknesses of the EVFS program as an analytic tool for transportation planners. The study applied the program to a 31.5-mile segment of I-81 between Hollins and Christiansburg. The authors concluded that there were four basic exclusive vehicle strategies provided by the EVFS program. Each of these strategies can be implemented using either a nonbarrier or barrier separated design.

- Inside lane: light vehicles only,
- Inside lane: heavy vehicles only,
- Outside lane: light vehicles only, and
- Outside lane: heavy vehicles only

Vidunas and Hoel found that the EVFS program was a valuable analytic tool that provides transportation planners with useful decision making information. The authors also noted that the most difficult part of performing an economic evaluation of a strategy such as exclusive lanes are accounting for all of the costs and savings that are accrued over the life span of the measure *(6)*.

In a concurrent study Wishart and Hoel *(7)* examined problems with mixed vehicle traffic and the four truck traffic strategies described in the EVFS program. The study considered a number of variables with safety, highway operations, and pavement deterioration being the dominant factors. The authors found that mixed vehicle travel is associated with higher risk, especially for the occupants of smaller or lighter vehicles, and that one contributing factor for crashes is the difference in operating characteristics of trucks and passenger cars. Wishart and Hoel concluded that when properly implemented, adequately publicized, and sufficiently enforced, truck traffic strategies can effectively increase safety, improve traffic operations, and decrease the pavement deterioration rate on interstate highways. The benefits considered in the study included savings in travel delay, reduced vehicle operations costs, decreased environmental impact from exhaust and fuel consumption, and injury and property damage savings from reduced crashes. Costs included engineering costs, construction costs, right-of-way acquisition costs, signage, enforcement costs and increased maintenance *(7)*.

In a 1997 Virginia Transportation Research Council report, Hoel and Vidunas *(8)* examined the economics of exclusive vehicle facilities defined by the EVFS program. The authors found that although no single factor is predominant, there are a number of factors that contribute to the feasibility of exclusive lanes. These factors include traffic volume, vehicle mix percentage, crash rate, and maintenance and construction costs. Maintenance and construction costs are given more weight in EVFS than other factors *(8)*.

Hoel and Vidunas found that the EVFS program had both strengths and weaknesses in its ability to accurately predict the feasibility of exclusive lanes. The strengths include an ability to analyze a number of alternatives for a variety of conditions and it is inexpensive. Weaknesses noted are an inability to differentiate between lanes and its unsuitability for evaluating alternatives, which use barriers *(8)*.

Feasibility Study of Reserved Capacity Lanes in Washington State

In 1996, Trowbridge et al. *(9)*, considered the impacts that would occur from providing trucks reserved capacity lanes that are in some cases separate from general traffic. The authors reference a study by BST Associates *(10)* in 1991 that found that trucks generally make up less than 5 percent of average daily traffic in urban areas, and note that an undue amount of effort is used devising strategies to restrict and manage this small portion of total traffic. In lieu of strategies restricting truck traffic, the authors propose providing trucks access to reserved capacity lanes— i.e. high occupancy vehicles (HOV) lanes— in order to relieve congestion.

The reserved capacity lanes investigated consisted of two options for roadways in the Seattle area. The first option permitted heavy trucks to use existing HOV lanes, while the second option added a lane for the exclusive use of trucks on all facilities that had an existing or planned HOV lane. The authors attempted to determine the impacts of these options on vehicle travel time and vehicle miles traveled for single occupancy vehicles (SOVs), HOVs, and trucks. The authors collected traffic data and performed a traffic simulation and an estimate of the economic impacts of this type of strategy. This strategy would provide the following estimated benefits:

- Estimated $10 million in savings in truck travel time,
- Estimated 2.5 minutes time savings per average trip (this is less than an 8 percent savings of an average trip), and
- Estimated $30 million in savings for SOVs *(9)*.

Estimated costs would be increased expenses due to pavement deterioration in the reserved capacity lane; however, there would be decreased expenses for pavement deterioration in other lanes. The net effect of this would be a small increase in capital expenditures. Trowbridge et al., estimated that the overall impact on safety of using reserved capacity would be negligible *(9)*.

Feasibility Study for Urban Truck Lanes in the United Kingdom

In 1985, the Department of Transport with the Civic Society and County Surveyors' Society commissioned a Lorry Management Study *(11)*. The study examined ways to reduce the impact of heavy truck traffic on urban areas and on traffic operations. Four areas were selected for study: Lancaster/Morecambe, Trafford in Greater Manchester, Worcester, and Elstree/Radlett in Hertfordshire. An urban truck lane was proposed for the Lancaster area to enable trucks to avoid a congested shopping area. The truck lane was not implemented due to concerns for pedestrian traffic from a nearby bus station. The study did conclude that in some instances priority truck lanes were a feasible alternative and merit consideration *(12)*.

EXCLUSIVE TRUCK LANES AND SELECTED LANE RESTRICTIONS IN U.S.

Capital Beltway Lane Restriction (Inside Lane: Light Vehicle Only, Non-Barrier Separated)

The Virginia Department of Transportation (VDOT) instituted a lane restriction for trucks in December 1984 on a section of I-95 that is part of the Washington, D. C. Capital Beltway. The section is in the southeast quadrant of the Beltway between I-395 and the Woodrow Wilson Bridge (near the Virginia state line). The restriction, which initially was implemented jointly with the State of Maryland, was an attempt to reduce crashes on the Capital Beltway. Following an initial trial period using lane restrictions on its portion of the Capital Beltway, Maryland chose to remove the lane restriction due to a lack of clear evidence of improvement.

The Highway and Traffic Safety Division of VDOT conducted a study of crashes, speeds, and volumes for one year prior to implementation of the restrictions. The objective of the before/after study was to assess the impact of the truck restriction on this segment of I-95 by comparing traffic volume, speed, and crash data prior to the restriction with that during the restriction *(13)*. Findings indicate that the lane restriction caused a redistribution of trucks in the non-restricted lanes while passenger vehicles using the left lanes increased slightly. An opinion survey of drivers indicated that the majority of users of the Beltway support a truck-free lane.

The number of crashes along the restricted area of the Beltway remained constant. However, the crash rate declined slightly with the restriction, and there was a 20 percent reduction in injury crash severity. It should be noted that the 20 percent reduction in crash severity is actually only a reduction of injury crashes by eight (41 versus 33). Property-damage-only crashes increased during the time period by nine (60 versus 69). Therefore, the reduction is probably insignificant. The overwhelming public support for the restriction and the perception of the benefits, in conjunction with the slight reduction in crash rates, resulted in a recommendation that the truck lane restriction be maintained *(13)*.

Follow-on studies of the Virginia I-95 data continued to evaluate crashes, speeds, and volumes to determine the effects of the restriction *(14, 15)*. In 1987, the Traffic Engineering Division of VDOT updated the initial 1985 Capital Beltway study. This update determined that the crash rate increased 13.8 percent during the restriction; however, there was no change in fatal and injury crash severity. Traffic volume increased nearly 8 percent during the time the restriction was in place. The only significant change for the segment was the lane restriction. The crash rate for the section consisting of the I-95, I-495, and I-395 interchange was the primary contributor to the overall crash rate increase. It was found that crashes were redistributed by lane of occurrence, type of maneuver, and collision type during the restriction.

Although the data showed an increase in crash rates, the authors noted that there was no change in fatal or injury crash severity. This maintenance of crash severity level along with various intangible benefits such as favorable public perception and continuity of the lane restriction with Maryland, resulted in a recommendation to retain the restriction *(14)*.

The Traffic Engineering Division of VDOT issued a final study update in June 1989. This study included the results of a field study of interchange ramps and loop geometrics. The field study was conducted to determine if these locations were properly posted with a maximum safe speed for the existing superelevation. Crash frequency and characteristics were then analyzed to determine the interface between drivers, vehicles, and roadway condition. Finally the study team performed an exploratory evaluation of the Northern Virginia (NOVA) Freeway Management Team *(15)*.

An analysis of the data showed that the crash rate increased for trucks on southbound I-95 during the truck lane restriction. The four most prevalent factors in crashes involving trucks were weather/visibility, vehicle defect, speeding, and road defect. Trucks were involved in 49 percent of the sideswipe collisions and 16 percent of the rear-end collisions. As a result of increases for two consecutive years, the authors recommended that the truck lane restriction be lifted *(15)*.

Puget Sound Lane Restriction (Inside Lane: Light Vehicle Only, Non-Barrier Separated)

Mannering, Koehne, and Araucto conducted a study in the Puget Sound region that considered lane restrictions as a means of increasing roadway capacity, improving highway operations, improving the level of roadway safety, and encouraging uniform pavement wear across lanes *(16)*. The study region has a truck volume of approximately 5 percent of the total traffic volume. The study consisted of a literature review; an in-depth analysis of the effects of restrictions at a specific site; a site comparison analysis to determine if there was enough consistency among various sites to apply the results of the in-depth analysis to other areas; and surveys of motorists to determine awareness and opinions of the driving public about the lane restrictions.

The literature review revealed that although a number of states had instituted truck lane restrictions, very few states had documented the effects of the restriction. In nearly every instance where a comprehensive examination of a lane restriction implementation occurred, negligible changes in operations and safety were observed *(16)*.

The in-depth analysis by the research team examined traffic composition, traffic flow characteristics, safety, enforcement issues, economic impacts, and pavement deterioration. The analysis revealed no significant operational or safety level increases that could be attributed to the restriction. The safety portion of the analysis did reveal that the number of truck related crashes for each lane was proportional to the number of trucks traveling in that lane. The portion of the in-depth analysis that addressed enforcement issues focused on violation rates. Researchers found that the violation rates for trucks during the restriction was 2.1 percent, which was the same as the proportion of trucks in that lane prior to the restriction. Therefore, the restriction had no noticeable impact on the distribution of the trucks. Researchers also found that the economic impact of the restrictions was minor for motor carriers, and there was only a minimal impact on pavement life. The authors recommended that truck lane restrictions not be implemented in the Puget Sound area *(16)*.

Los Angeles Truck Bypass Lanes (Truck Separation Lanes)

Interstate 5 north of Los Angeles is a corridor with a very heavy volume of truck traffic. In the 1970s, Caltrans built truck bypass lanes on I-5 near three high volume interchanges. The lanes were built to physically separate trucks from other traffic and to facilitate weaving maneuvers in the interchange proper. The first truck facility encompasses the section of I-5 which includes the Route 14 and Route 210 interchanges. The other truck facilities are at Route 99 near Grapevine and at the interchange of Route 110 and I-405. Although these facilities were built for truck bypass of the interchanges, automobiles and other vehicles use the lanes. Trucks are restricted to the right lane in California *(17)*.

Detailed information regarding the construction cost of the bypass lanes is scarce. However the reason cited by Caltrans engineers for building the truck lanes was to reduce weaving problems. The truck bypass lanes are typically two lanes and have received mixed reviews. Many passenger car drivers use them instead of going through the interchange in order to avoid weaving. Truck drivers would prefer to restrict the bypass lanes to trucks only due to differences in vehicle operating characteristics between the two vehicle classes and because of an apparent lack of understanding by auto drivers of truck operating characteristics *(17)*.

New Jersey Turnpike Dual-Dual Roadway (Inside Lanes: Light Vehicle Only, Barrier Separated)

The New Jersey Turnpike has a 35-mile segment that consists of interior (passenger car) lanes and exterior (truck/bus/car) lanes within the same right-of-way. For 23 miles, the interior and exterior roadways have three lanes in each direction. On the 10-mile section that opened in November 1990, the exterior roadway has two lanes, and the interior roadway has three lanes per direction. Each roadway has 12-foot lanes and 12-foot shoulders, and the inner and outer flows are separated by a barrier. The mix of automobile traffic is approximately 60 percent on the inner roadways and 40 percent on the outer roadways *(17)*.

The separated facilities, which are also referred to as dual-dual segments, were implemented to relieve congestion. Other truck measures that have been implemented on the turnpike are lane restrictions and ramp shoulder improvements. The New Jersey Turnpike Authority (NJTA) was one of the first jurisdictions to impose restrictions for trucks. The restriction implemented in the 1960s does not allow trucks in the left lane of roadways that have three or more lanes by direction. On the dual-dual portion of the turnpike from Interchange 9 to Interchange 14, buses are allowed to use the left lane. The resulting effect is that the left lane becomes a bus lane with the right lane(s) occupied by trucks. The NJTA rates compliance for truck lane restrictions as high *(17)*.

Portland, Oregon Truck Bypass Lanes (Truck Separation Lanes)

A truck bypass facility exists on a section of northbound I-5 near Portland, Oregon at the Tigard Street interchange; it is similar to some of the California facilities. The bypass lane requires trucks to stay in the right lane, exit onto a truck roadway, and re-enter the traffic downstream of the interchange. Passenger cars are also allowed to use the bypass facilities *(17)*.

One reason this facility is needed is a significant grade on the main lanes of I-5. Without the truck roadway, larger vehicles would be forced to climb a grade, then weave across faster moving traffic that is entering the main lanes from their right. The resulting speed differentials caused by trucks performing these maneuvers created operational as well as safety problems prior to the implementation of the bypass facility. Observations of trucks traveling northbound indicated that nearly every truck uses the truck bypass. There is no before and after crash data for the truck bypass lane. However, Oregon DOT officials indicated that the removal of the slow-moving trucks from the complex-weaving section has substantially eliminated the operational problems at this site. Truck speeds are now typically 50 mph in the merge area; prior to implementation of the bypass lane, truck speeds were 20 to 25 mph. There was no specific cost data available for construction of the bypass lane *(17)*.

EXCLUSIVE TRUCK LANES AND SELECTED LANE RESTRICTIONS IN EUROPE

Bologna-Firenze Freeway in Italy (Exclusive Separate Truck Facility)

The Bologna-Firenze Freeway is an exclusive truck facility that was built as a result of concern about increasing traffic flow and congestion and a 40 mph cap on truck speeds. Italian engineers built the exclusive truck facilities to bypass areas with the greatest congestion problems. The Bologna-Firenze Freeway, a direct link between Northern and Southern Italy, was selected as the initial project *(2)*.

The exclusive truck facility, which traverses the Appennine Mountains, was built to improve the operating and safety conditions of the Bologna-Firenze Freeway. Freeway management found that the freeway was subjected to irregular traffic flows due to the terrain; that routine maintenance contributed to congestion and effective operations; and that there were high traffic volumes that included a high percentage of trucks. The recommendation for increasing effectiveness of the freeway consisted of constructing a new complementary freeway that would be reserved for heavy vehicles. The exclusive facility, which is a 33-mile section from Barberino del Mugello to Sasso Marconi, was designed with features to reflect the characteristics of trucks and area terrain. The design features for the area include: no sharp curves or undulations that limit sight distance; maximum grade of 2 percent; peak elevation of 490 meters, and extensive use of tunnels and bridges to traverse the mountainous terrain. Eighty percent of the truck facility is tunnels and bridges with one tunnel that is 8,000 meters in length *(18)*.

Paris Planned A86 Ring Motorway (Truck Bypass)

The A86 ring motorway is a tollway being built near Paris that will be managed by a private toll entity. The plans for the motorway call for the construction of two separate tunnels to bypass Versailles. The westside tunnel, between Rueil and Bailly, will serve mixed traffic (trucks and cars) and the eastside tunnel, between Rueil and Versailles, will be reserved for light vehicles only *(12)*. The mixed tunnel will have two lanes, will be slightly shorter than the light vehicle tunnel, and will have standard tunnel dimensions. The cars-only tunnel will consist of two levels (one on top of the other) with three lanes in each direction. According to proposed cross-sections, it will be built with a height of 8 foot 6 inches and lane widths of 10 feet. Construction on the tunnels is underway, but anticipated completion dates were not provided *(19, 20)*.

Southern Netherlands Proposed Truck Lanes (Truck Lanes, Non-barrier Separated)

In the Netherlands, a number of strategies are being considered in an attempt to relieve severe congestion and ameliorate increasing pollution in the region. One of the strategies being considered is the creation of a truck lane utilizing existing pavement and infrastructure. In areas with severe congestion and bottlenecks, particularly on roads between Randstad (an economic center in the Netherlands), Germany, and Belgium, truck lanes are seen as potentially helpful in combating congestion. Traffic managers are considering utilizing the paved shoulder on the roadway and restriping the existing roadway to allow four narrow lanes instead of the three existing standard width lanes. Another option being considered is separating through truck traffic from automobile traffic. The truck lanes would be 3.25 meters in width and the car only lanes would be 3.0 meters in width *(12, 21)*.

ISSUES REGARDING EXCLUSIVE LANES

The review of related literature reveals that a number of states have implemented strategies regarding truck lanes. In 1986, the Federal Highway Administration (FHWA) asked its division offices to conduct a survey and report on experiences encountered by states with lane restrictions. The most common reasons for implementing lane restrictions were:

- Improve highway operations (14 states)
- Reduce crashes (8 states)
- Pavement structural considerations (7 states)
- Restrictions in construction zones (7 states)

It should be noted that some states provided more than one reason for the restriction *(22)*.

Operational Issues

As previously stated, highway traffic operations are the "yardstick" by which the user measures the quality of service provided by a facility. The characteristics which matter most to the driver are the speed of travel, safety, comfort, and convenience. Highways are designed for a mix of vehicle types; however, an increased presence of large trucks on a roadway may result in serious degradation of flow quality for the following reasons.

- Trucks are significantly heavier than passenger cars.
- Trucks are considerably longer than other vehicles.
- Trucks have lower rates of deceleration and acceleration *(23)*.

In urban areas, the demand on the highway system has grown much more rapidly than the corresponding increases in available capacity. This increase in demand has led to high levels of congestion and an increased awareness for traffic operations. Correspondingly, the studies of effects of trucks on highway operations have also increased in recent years *(24)*.

Hanscom addressed the operational effectiveness of restricting trucks from designated lanes on multilane highways *(25)*. His study involved sites near Chicago and in rural Wisconsin. Measures of lane restriction effectiveness included voluntary truck compliance, traffic congestion as determined from speeds and platooning of vehicles following trucks, and an all-vehicle sample of differential speeds between the restricted and adjacent lanes. The author concluded that favorable truck compliance effects were evident at all three locations. However, violation rates were higher at the two-lane site as a result of increased truck concentrations due to the truck restriction. Reduced speeds of impeded vehicles following trucks were also more prominent at the two-lane site. At the three-lane sites, the results of the lane restriction were beneficial traffic flow effects and reduced congestion. No speed changes (between the restricted and adjacent lanes) were observed to indicate an adverse effect of implementing the truck lane restrictions.

In 1990, Zavoina, Urbanik and Hinshaw examined the effects of truck restrictions on rural Interstates in Texas *(26)*. This study analyzed the operational effects of restricting trucks from the left lane in Texas. Study sites were six-lane, rural interstate highway sections with speed limits of 65 mph for automobiles, and 60 mph for trucks. Vehicle distributions according to classification, vehicle speeds, and time gaps between vehicles were examined.

The study found no definitive safety improvements that could be attributed to the truck restriction. Although the lane distribution of trucks changed significantly due to the restriction, no safety effects were found that could be attributed to the truck restriction in terms of the lane distribution of cars, speeds of either cars or trucks, or the time gaps between vehicles. The authors also concluded that even though truck lane restrictions should theoretically improve the capacity and safety of a roadway, the research evidence did not support this assumption *(26)*.

A 1992 study by the OECD regarding Truck Roads examined operational issues regarding dedicated truck lanes and exclusive truck routes. The authors concluded that truck only lanes appear to be of limited value, because they reduce the operational flexibility of the road. Particular problems may arise when trucks attempt to overtake other trucks or where the road is heavily congested and trucks are traveling faster than vehicles in nonexclusive lanes. Another fear is that designating one lane exclusively for trucks would result in the saturation of that lane by trucks resulting in little to no operational benefit. Conversely the lane would receive limited use during holidays and weekends when truck traffic is relatively light *(12)*. One study conducted by the Netherlands found that the designation of a truck lane is feasible only when truck traffic density is in the range of 600-1,000 trucks per hour. Densities lower than this range would be inefficient lane usage, whereas higher truck traffic densities would result in bottlenecks *(27)*.

Safety Issues

Garber and Gadiraju *(28)* used a simulation technique to examine the effects of increased truck operations from implementing different strategies on multilane highways. The primary study objective was to provide information about the nature and extent of the impact of specified truck traffic control strategies. The strategies included lane restrictions and differential speed limits. The study found that (1) the combination of lowering the speed limit for trucks and restricting the trucks to the right lane increased the interaction between cars and trucks and therefore the potential for passenger car/truck crashes; (2) the restriction of trucks to the right lane decreased the vehicular headway in this lane, and (3) the combination of lowering the speed limit for trucks and restricting the trucks to the right lane resulted in a change in the distribution of vehicle spot speeds, and a slight, but statistically insignificant, increase of crashes on the right lane.

In research sponsored by the Maryland State Highway Administration, Sirisoponsilp and Schonfeld *(29)* in 1988 reported on the strategies used by state highway agencies to restrict trucks from certain lanes and the impact that those restrictions had on traffic operations and safety. The authors concluded that although truck lane restrictions have been imposed by a number of states for many years, the effects of the restrictions on traffic operations and safety are still not well-known, and cost effectiveness is uncertain. The goal of restricting truck lane usage appears to have shifted from traffic operation to traffic safety. This shift stems from public perceptions of increased truck-related crashes. Truck lane restrictions have not been accepted as a potential solution to the congestion and crash problem on urban freeways.

In 1984, McCasland and Stokes *(30)* examined truck traffic characteristics and problems on urban freeways in Texas. The study evaluated six truck restrictions and regulatory practices through information obtained from a literature review and a survey of state policies. The regulations and restrictions examined were lane restrictions; time-of-day restrictions; speed restrictions; route restrictions; driver licensing and certification programs; and increased enforcement of existing regulations. Results indicated that the restriction of truck traffic to one mixed-flow lane would probably not improve freeway safety or operations based on associated constraints and limitations. The authors also concluded that only reduced speed limits for all vehicles, improvement of driver licensing/training, and incident management techniques appear capable of producing any substantial improvement in the safety and operational aspects of truck usage of urban freeways in Texas. However, it should be noted that all assessments and recommendations are based on findings of the literature review and state policy survey (30).

One area of particular concern when implementing truck restrictions on urban freeways is the creation of a "barrier effect" in weaving areas. Weaving areas are segments of freeway formed when a diverge area closely follows a merge area. Operationally, weaving areas are of concern because the "crossing" of vehicles creates turbulence in the traffic streams. When trucks are restricted to the rightmost lanes of a freeway and are of significant numbers, a barrier composed of trucks can form in the weaving areas. Trucks limit the visibility and maneuverability of smaller vehicles attempting to enter and exit the freeway system. An indication of the barrier effect is an over-involvement of trucks in weaving area crashes, rear-end collisions, and side collisions. Some studies have shown that this problem may be magnified when a differential speed limit is present *(29, 30)*.

In 1989 Garber and Joshua *(31)* examined large truck crashes on Interstate highways in Virginia for the period from 1983 to 1985. The following characteristics of truck crashes were documented ("non-large trucks" refer to all vehicles except large trucks).

- Thirty-five percent of non-large truck crashes involve one vehicle, while only 22 percent of large truck crashes involve one vehicle.
- Sixty-nine percent of large truck crashes involve two vehicles and 59 percent of non-large truck crashes involve two vehicles.
- Nine percent of large truck crashes involve three or more vehicles and 6 percent of non-large truck crashes involve three or more vehicles.

The authors also found that when a large truck is involved in a two-vehicle crash, non-large trucks were involved 94 percent of the time. There is a temptation to conclude that this over-representation is due to the high percentage of non-large trucks. Therefore, the analysis used a binomial theorem to compare the actual and expected proportions of crashes based on vehicle-miles traveled. The proportion of non-large trucks involved in two vehicle crashes with large trucks was indeed larger than expected, so safety may be enhanced by reducing interaction between the two vehicle types *(31)*.

Garber and Joshua also investigated fatal crashes. They found that, for non-large trucks, 68 percent of the fatal crashes were one-vehicle crashes. However, when large trucks were involved in fatal crashes, there were two vehicles involved in the crash 60 percent of the time. In multiple vehicle crashes involving a large truck, fatalities are 40 times more likely than when the crash involves only non-large vehicles. Garber and Joshua therefore concluded that safety could be enhanced by reducing interactions between the two types of vehicles, and the number of fatal crashes could be reduced *(31)*.

Economic Issues

Cambridge Systematics, Inc. *(32)* assessed the impacts of large trucks on freeway congestion in a 1988 study sponsored by the California Department of Transportation. Sites for the study consisted of Los Angeles, San Francisco, and San Diego, three areas that were identified as critically congested areas. The objectives of the study were to assess the impacts of large trucks on peak-period freeway congestion; evaluate the effects of freeway and traffic management techniques on congestion reduction; and identify the economic impacts of freeway and traffic management techniques. The study found that the volume of large trucks on freeways does not have an inordinate impact on peak period congestion; however, truck-involved crashes and incidents do have a significant impact on freeway congestion. The four strategies proposed to reduce congestion were a traffic management program, an improved incident management program, night shipping and receiving policies, and peak-period truck bans.

Peak-period truck bans would temporarily reduce congestion on core freeways; however, congestion would correspondingly increase on parallel arterial routes. Although the authors judged that peak-period truck bans would not be legal under the federal Surface Transportation Assistance Act of 1988, possible impacts of bans were examined due to the favorable perception of bans by the media and general public. The study found that the ban, which would cost the Los Angeles study site alone $22 million in direct costs, would improve speeds slightly on freeways, but adjacent surface street speeds would drop. The estimated reduction in total California business sales due to a peak period ban was $27 million *(32)*.

When Trowbridge et al., investigated the possibility of using reserved capacity lanes as exclusive truck lanes in the Seattle area, the benefit and cost of the strategy were estimated. Based on current traffic data and simulation, the following economic impacts resulted:

- Estimated $10 million in savings in truck travel time,
- Estimated 2.5 minutes time savings per average trip (this is less than an 8 percent savings of an average trip), and
- Estimated $30 million in savings for SOVs *(9)*.

The economic analysis reflected increased pavement deterioration in the reserved capacity lane and decreased pavement deterioration in other lanes. The net effect would be a modest overall increase in cost due to pavement deterioration and the consequent increased maintenance *(9)*.

When Wishart and Hoel *(7)* investigated exclusive truck facilities in Virginia using EVFS, a list of expected benefits and costs were described. Broad intended benefits of separating truck traffic from automobiles included improved operations, reduced crashes, less severe crashes, and fewer and shorter delays. Other expected benefits are: savings from reduced travel delay; reduced vehicle operation cost; decreased environmental impact from exhaust and fuel consumption; and injury and property damage savings. These benefits are offset by expected costs in engineering; construction; additional right-of-way; signage; enforcement; and maintenance *(7)*. It should be noted that although expected costs may outweigh the benefits, many of the costs are one time costs, while the benefits are recurring.

Legislative and Political Issues

Truck restrictions have been implemented by a number of states in an attempt to increase safety, decrease congestion, and improve operations. The most prevalent form of restriction by far is lane restrictions. State transportation officials usually have the authority to implement lane restrictions. In many instances, local jurisdictions have the authority through existing legislation to implement restrictions on state highways. Table 1 lists states that have existing legislation regarding truck restrictions *(33)*.

It should be noted that STAA in 1982 and TTSA in 1984 established a national network of highways as a designated large truck network. The law is insistent that state regulations should not interfere with interstate truck movements, as long as the trucks conform to size and weight limits established by STAA and TTSA *(33)*.

In May 1997, Texas passed legislation that permits a municipality to request lane restrictions on certain highways within the municipality's jurisdiction. The request for lane restriction must be approved by the Texas Department of Transportation (TxDOT). Specific criteria must be met prior to TxDOT's approval of a municipality's request. For example, the highway must be a state-maintained controlled access facility with at least three through-lanes in each direction, and an engineering study must be conducted by TxDOT to determine the feasibility of the proposed lane restrictions. To comply with this legislation, Jasek et al. developed guidelines to aid TxDOT in the implementation of requested truck lane restrictions in urban areas *(24)*.

The guidelines provide TxDOT with the necessary information to evaluate a municipality's request for lane restrictions. Researchers recommended a 12-step process to provide guidance on information related to the proposed lane restrictions that must be contained in the ordinance. The process would include conducting a traffic study, removing/installing the appropriate traffic control devices, and periodically reviewing the lane restrictions to ensure against any negative impacts that may result from the lane restrictions. Researchers recommended that TxDOT monitor the extent to which truck lane restrictions are requested by municipalities. If truck lane restrictions became prevalent, TxDOT should request legislation that would make the restrictions statewide *(24)*.

Table 2.1 Truck Restrictions by State

State	Restriction
Arkansas	Restricts trucks to leftmost lane(s). Voluntary not enforced.
California	Restricts trucks to rightmost lane(s). Restricts trucks with 3 or more axles on roadways that have a minimum of 2+ directional lanes
Colorado	Restricts trucks in certain areas to rightmost lane(s).
Connecticut	Restricts trucks to rightmost lane(s) on freeways with 3+ directional lanes statewide.
Florida	Restricts trucks with 3 or more axles from leftmost lane(s) in certain areas. (Broward and Palm Beach County). Operational 7:00 a.m. to 7:00 p.m.
Georgia	Restricts trucks to rightmost lane(s) if trucks are allowed by permit to travel within the I-285 perimeter freeway in Atlanta area.
Idaho	Restricts trucks in certain locations with minimum of 2+ directional lanes to leftmost lane(s)
Illinois	Restricts trucks on facilities with a minimum of 3+ directional lanes to rightmost lane(s)
Indiana	Restricts trucks on facilities with minimum of 2+ directional lanes to rightmost lane(s)
Kentucky	Restricts trucks with a gross vehicle weight (GVW) of 30,000 lbs. to the rightmost lanes on roadways with 3+ directional lanes
Louisiana	Restricts trucks in some areas to rightmost lane(s)
Maryland	Restricts trucks in some areas with grades to rightmost lane(s)
Massachusetts	Restricts trucks with a GVW of 10,000 lbs. in certain areas to rightmost lane(s)
Missouri	Restricts trucks on all urban freeways with a minimum of 3+ directional lanes to rightmost lane(s).
Nevada	Restricts trucks in certain areas to leftmost lane(s). Voluntary restriction.
New Jersey	Restricts trucks with a GVW of 10,000 lbs. to rightmost lane(s) on urban freeways with 3+ directional lanes.
New York	Restricts trucks with a GVW of 10,000 lbs. to rightmost lane(s) on certain urban freeways with 3+ directional lanes.
North Carolina	Restricts trucks to leftmost lane(s).
Oregon	Restricts trucks with a GVW of 8,000 lbs. to rightmost lane(s) on urban freeways with 2+ directional lanes.
Pennsylvania	Restricts trucks to rightmost lane(s) on grades.
Texas	Restricts trucks to rightmost lane(s) on freeways with 3+ directional lanes in certain areas.
Virginia	Restricts trucks to rightmost lane(s) on limited access facilities with 2+ directional lanes .
Wisconsin	Restricts trucks in certain rural areas to leftmost lane(s).

Environmental Issues

Environmental issues are concerns for most urban areas. Congestion requires vehicles to move more slowly, thereby worsening noise and pollution levels. Trucks moving in a free-flow traffic environment generate a minimum amount of exhaust pollution, and fuel consumption is minimized. Traveling the same mileage under congested conditions results in significantly increased pollution levels and fuel consumption. One of the expected results of implementing truck lanes noted by Wishart and Hoel is a reduction in environmental impacts from exhaust and fuel consumption *(7)*.

A study by the OECD *(12)* also examined the impact of truck facilities and truck lanes on the environment. The environmental issues considered were noise and vibration pollution, fuel consumption, and air pollution. According to this study, the air pollution produced by trucks is quite different from the pollution produced by cars. Trucks are primarily powered by diesel engines that operate with higher air/fuel ratios than the gasoline engines that power most cars. Diesel engines produce less carbon monoxide and unburnt hydrocarbons than gasoline engines. However diesel engines produce more smoke and solid particles due to the richer fuel/air mix. Vehicle emissions and energy consumption increase with traffic congestion and speed variations. Speed variations can increase both emissions and fuel consumption by 25 to 40 percent, while traffic congestion can increase emissions and fuel consumption by 50 to 100 percent *(12)*.

In 1989 a special conference on the environment was held by the European Conference of Ministers of Transport *(34)*. The reports presented to the conference discussed various concerns regarding environmental damage caused by traffic and traffic congestion. The conference compared the pollution due to trucks versus automobiles. One conclusion reached was that given the current state of traffic a 10 percent reduction in traffic congestion for trucks would result in a significant decrease in environmental pollution while a 10 percent decrease in traffic congestion for automobiles would be inconsequential *(34)*.

Social and Public Opinion Issues

The most significant obstacle to exclusive truck facilities may be public opinion. In the reserved capacity feasibility study by Trowbridge et al., an attitudinal study of motorists and the general public examined opinions regarding the use of HOV lanes by trucks. The response by the general public indicated considerable resistance to any strategy that was perceived as a special benefit to truck traffic. However, it should be noted that the general public was favorable to truck lane restrictions. Individual comments included responses (19 percent) that trucks were unable to maintain constant speed or traveled at different speeds. Some individuals (13 percent) viewed trucks as dangerous or unsafe *(9)*.

The OECD report on Truck Roads *(12)* verified that exclusive truck lanes would be unpopular with the general public. Public acceptance of a facility depends on whether individuals find the facility useful. In the case of an exclusive truck road, people living near the facility do not perceive a direct benefit and may oppose the facility. Once again, although public opinion is negative toward exclusive facilities, the public generally favors the restriction of trucks to specific lanes *(12)*. This acceptance of restrictions is consistent with public input on the Capital

Beltway truck lane restrictions. In this specific case, public opinion was so favorable that lane restrictions were maintained even though there was no indication of improved traffic operations or a reduction of crashes *(13, 14, 15)*.

Project Financing Issues

As briefly discussed in the Economic Issues section of this report, the costs associated with implementing separate truck facilities can be prohibitive. Some entities have used innovative means to finance such projects. The New Jersey Turnpike Authority was created by the New Jersey Legislature in 1948 "...to construct, maintain, repair, and operate Turnpike projects" (*35*). The New Jersey Turnpike consists of 148 miles of roadway, including the portion which is a dual-dual roadway discussed in a previous section is a self-supporting operation. Turnpike construction projects are financed through the issuance of bonds. The bonds are repaid by revenue from tolls, turnpike concessions, and investments. No tax dollars have ever been used for turnpike operations (*35*).

A similar method has been successfully used by Italy to finance the Bolonga-Firenze as well as other Italian toll facilities and the Paris Ring Motorway facilities. In Italy the Societ Autostrada was formed in 1956 to build and manage a toll facility between Milan, Rome, and Naples. Motorway funding was provided by bonds, which were guaranteed by the Italian government. Revenue from tolls and concessions were used to repay the initial costs and maintain the roadway (*36*). The Paris Ring Motorway is similarly financed.

Chapter 3
Data Collection

I. INTRODUCTION

The Task 3 Report documents the SR-60 corridor's characteristics relevant to the evaluation of the feasibility of constructing commercial vehicle lanes from I-710 to I-15. The Task 4 Report (to follow) analyzes these characteristics to form the basis for the evaluation of conceptual alternative improvements to be developed in Task 5. For purposes of this study, commercial vehicles with 3 or more axles, or those vehicles considered to be "Heavy Duty Trucks", were evaluated. Commercial vehicles considered "light and medium duty" (with 2 axles) were not evaluated for this study and are not included in this report (other than as part of overall traffic flow). References to the sources used to obtain the information used as the basis of this report are also presented.

The SR-60 corridor characteristics related to heavy-duty truck activity were grouped into three areas: physical, operational, and safety characteristics. Physical characteristics include information that describes the current freeway design and physical layout of the corridor. Operational characteristics include descriptions of the usage of the freeway for goods movement in particular. Finally, safety characteristics related to heavy-duty truck accidents and incidents were evaluated to identify the soundness of the SR-60 corridor.

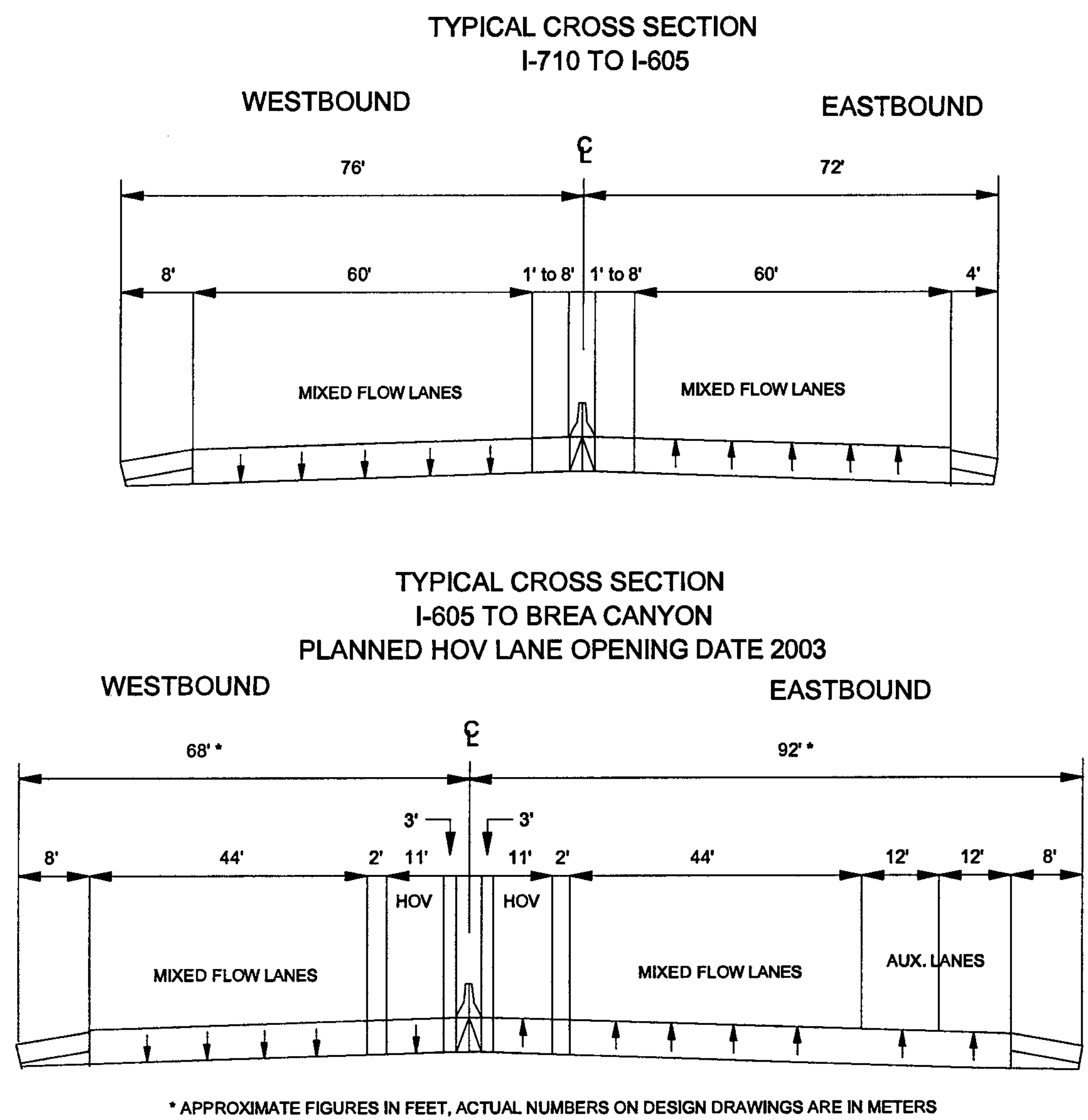
II. PHYSICAL CHARACTERISTICS

A number of factors were used to describe the physical characteristics of SR-60. In order to assess the feasibility of commercial vehicle lanes in the corridor, the following factors were reviewed and evaluated:

- number of freeway lanes;
- typical freeway cross-sections;
- land uses adjacent to the corridor;
- freeway overcrossings (or undercrossings) and their associated clearances; and
- right-of-way (ROW) along the corridor.

Several sources were used to obtain the above information. They included aerial photographs provided by Caltrans, as-built engineering drawings also provided by Caltrans, studies of high occupancy vehicle (HOV) lane proposals on the Pomona Freeway conducted by Caltrans, and other field work investigations conducted for this study and other local studies, within the SR-60 corridor. (It should be noted that HOV lanes are proposed for the SR-60 section between I-605 and Brea Canyon Road with an opening date scheduled for April 2003. Since the funding for this project has been committed and programmed, the HOV lanes for this section of the SR-60 were considered to be part of the study corridor analysis.)

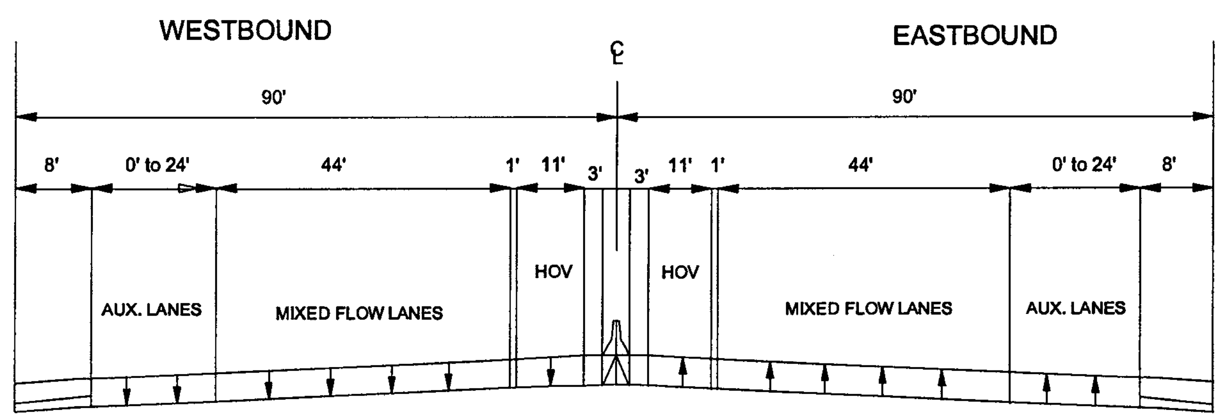
Figures 1 and 2 illustrate typical cross-sections of the SR-60 corridor. The other physical characteristics reviewed and evaluated, are documented in Figures 3a through 3j.



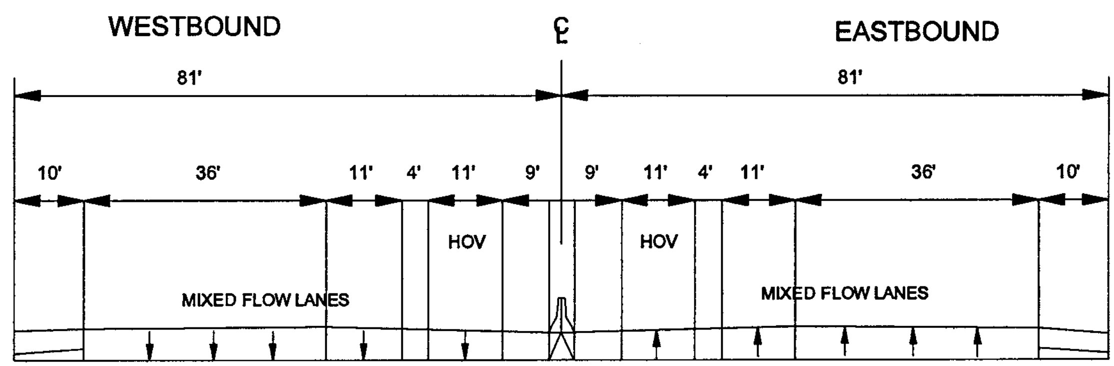
KAKU ASSOCIATES

Figure 3.1
TYPICAL CROSS SECTIONS
I-710 TO BREA CANYON

TYPICAL CROSS SECTION
BREA CANYON TO SAN BERNARDINO COUNTY LINE



TYPICAL CROSS SECTION
SAN BERNARDINO COUNTY LINE TO I-15



KAKU ASSOCIATES

FIGURE 3.2
TYPICAL CROSS SECTIONS
BREA CANYON TO I-15

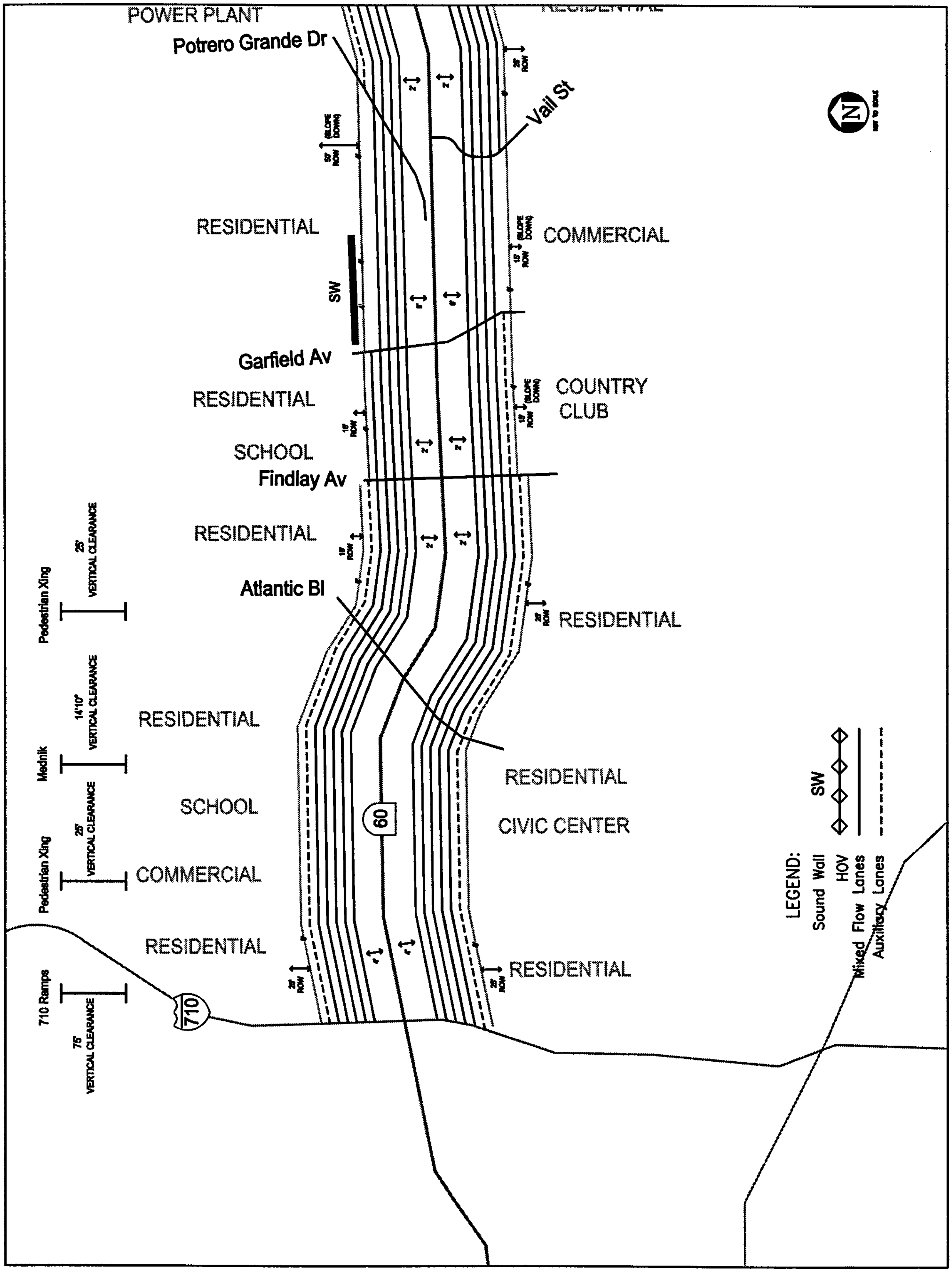


FIGURE 3.3-A
SR-60 PHYSICAL CHARACTERISTICS

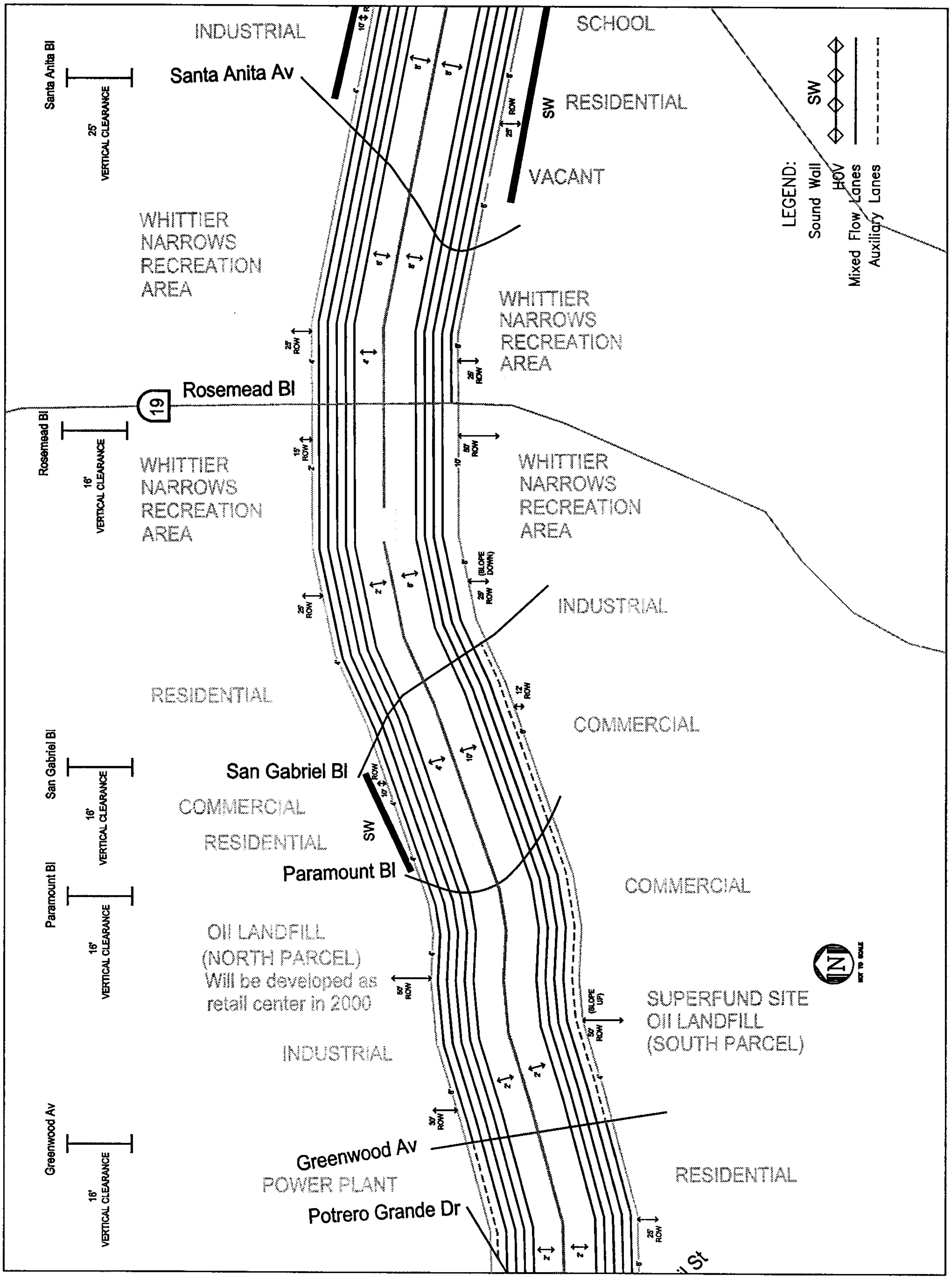


FIGURE 3.3-B
SR-60 PHYSICAL CHARACTERISTICS

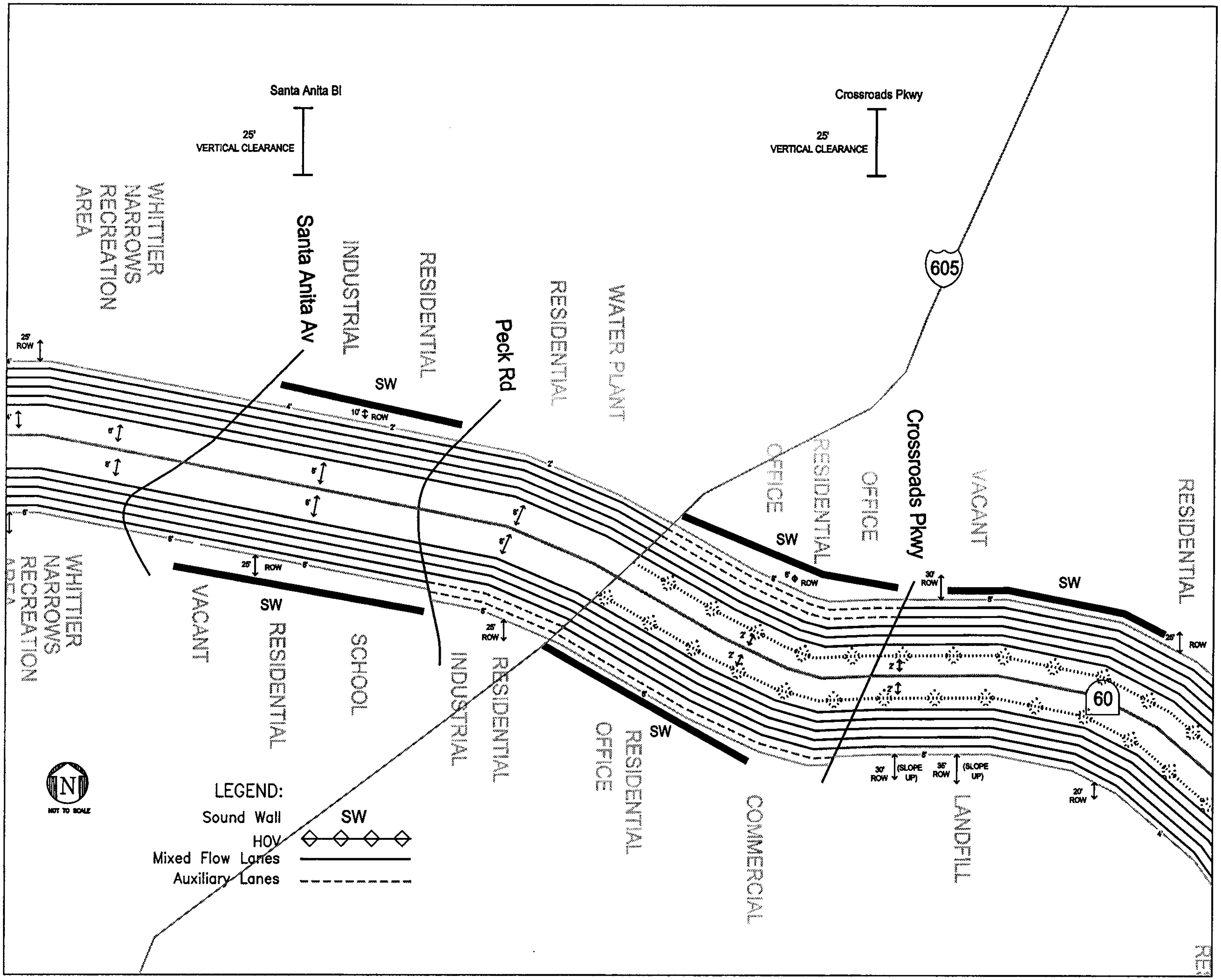


FIGURE 3.3-C
SR-60 PHYSICAL CHARACTERISTICS

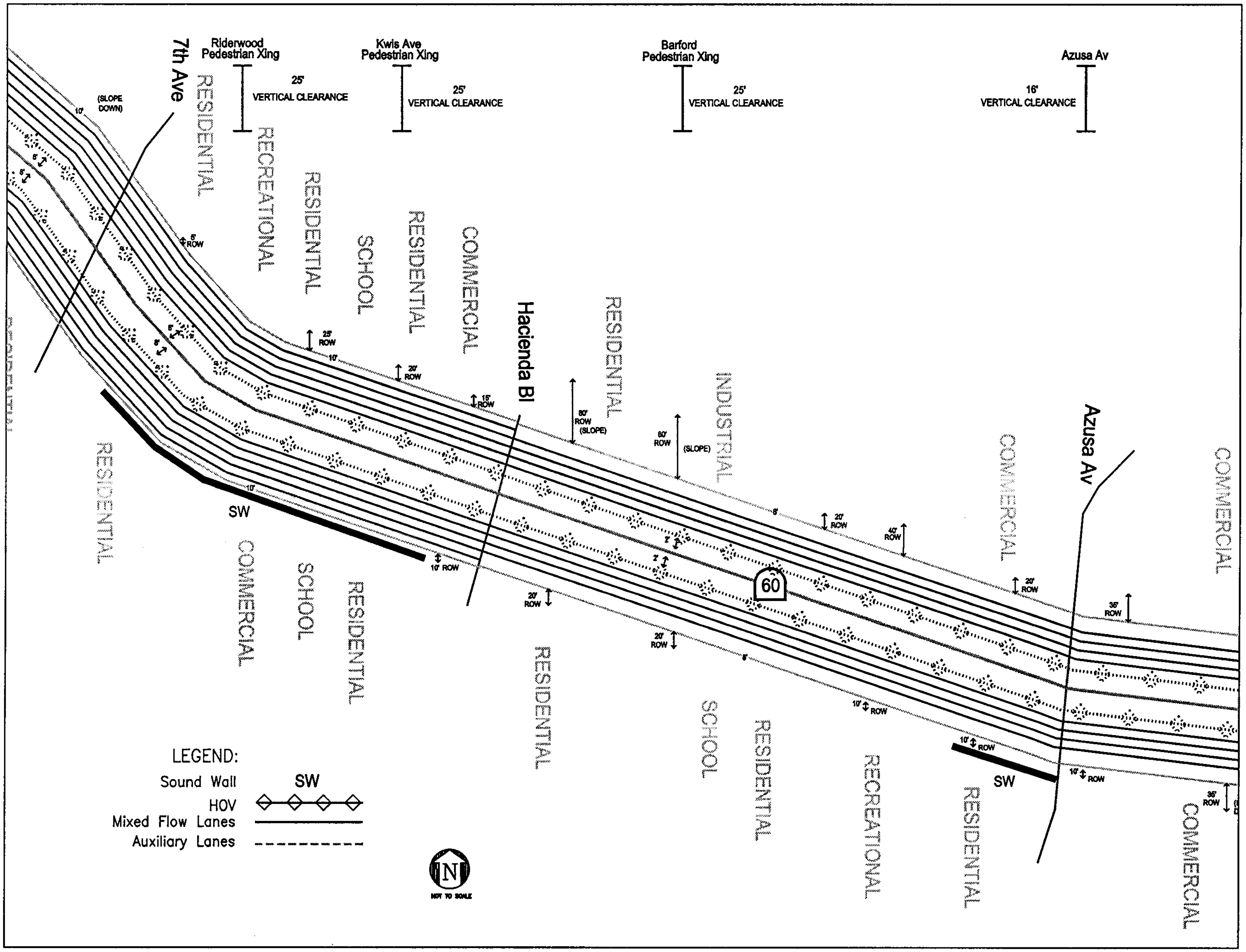


FIGURE 3.3-D
SR-60 PHYSICAL CHARACTERISTICS

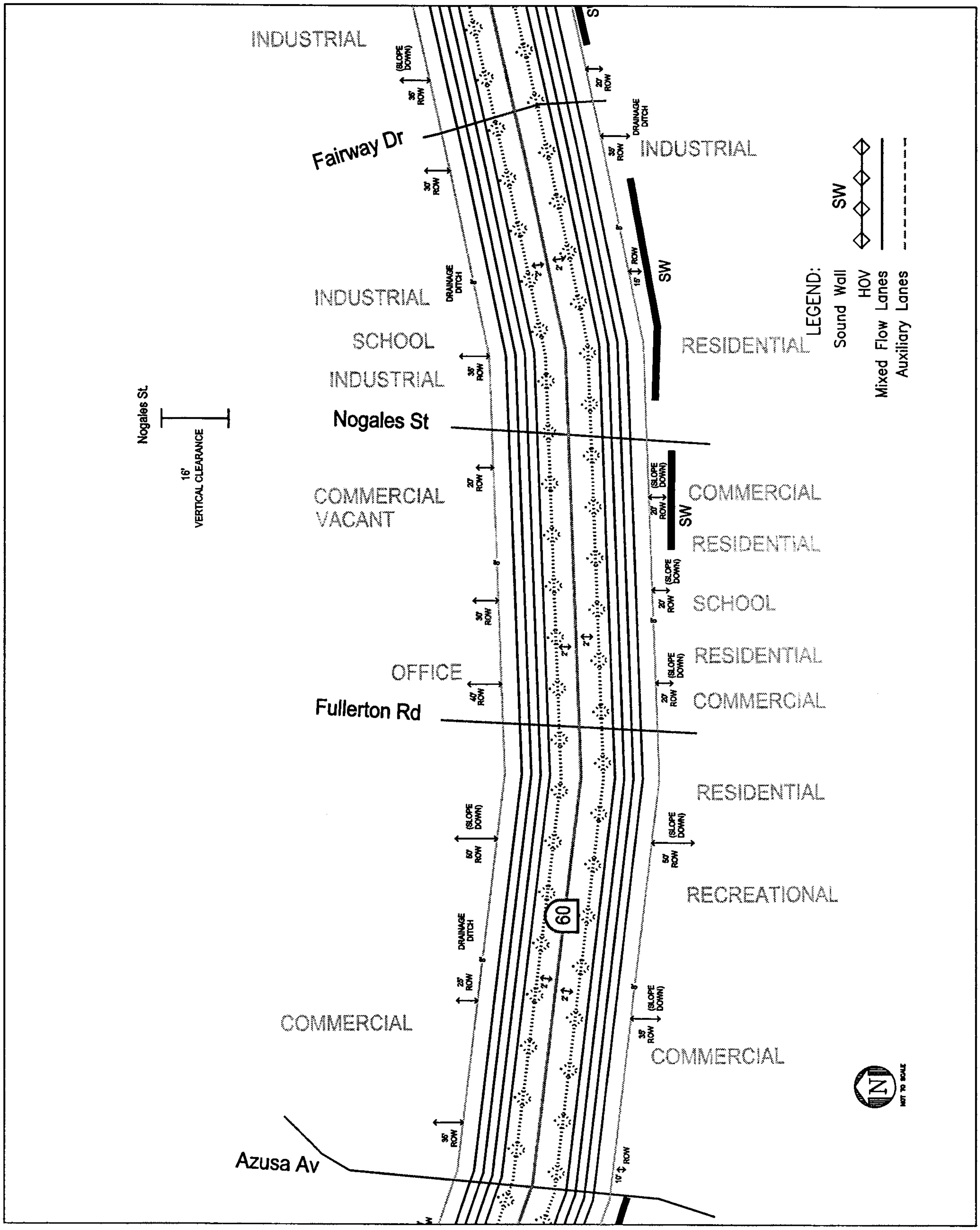


FIGURE 3.3-E
SR-60 PHYSICAL CHARACTERISTICS

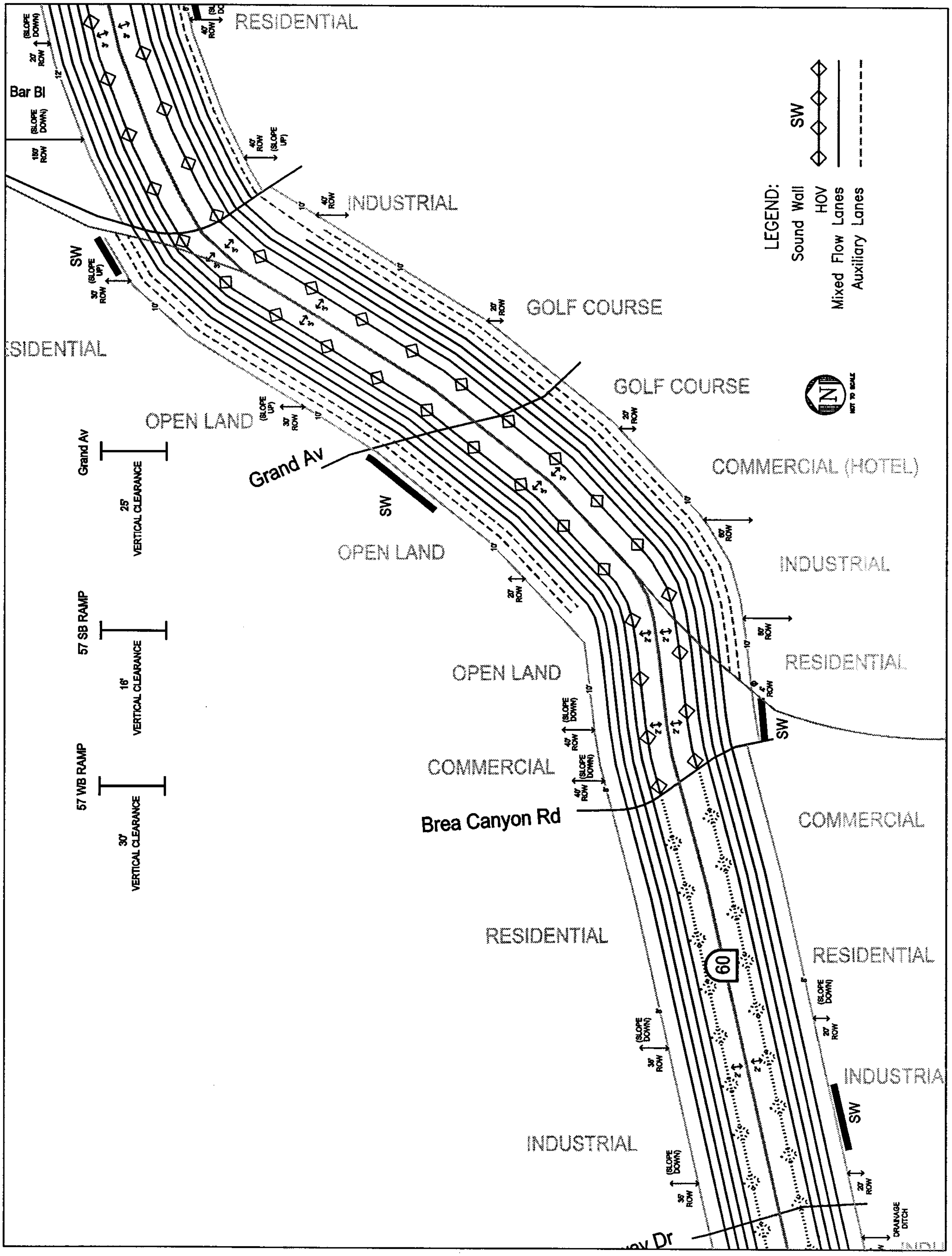


FIGURE 3.3-F
SR-60 PHYSICAL CHARACTERISTICS

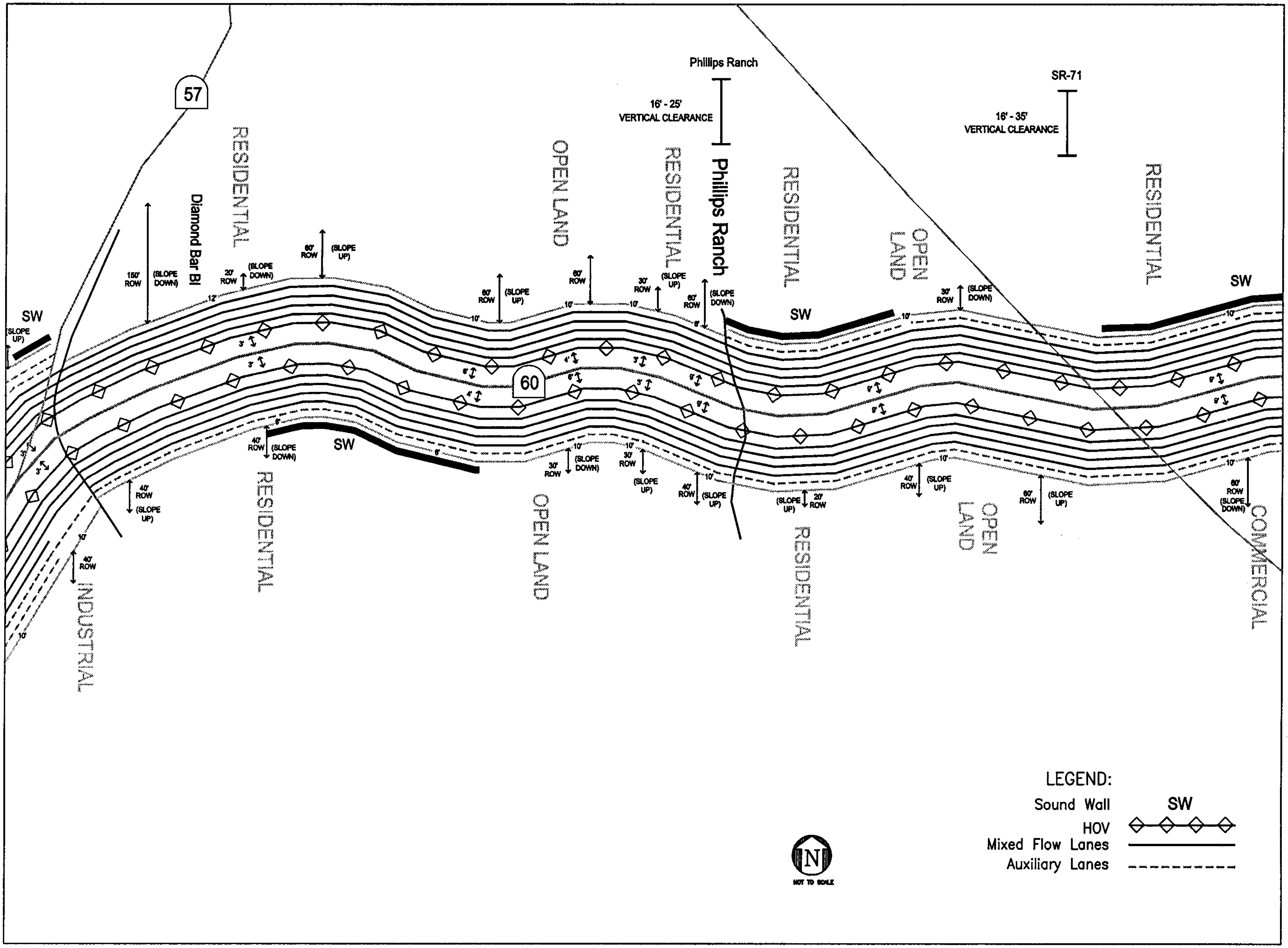


FIGURE 3.3-G
SR-60 PHYSICAL CHARACTERISTICS

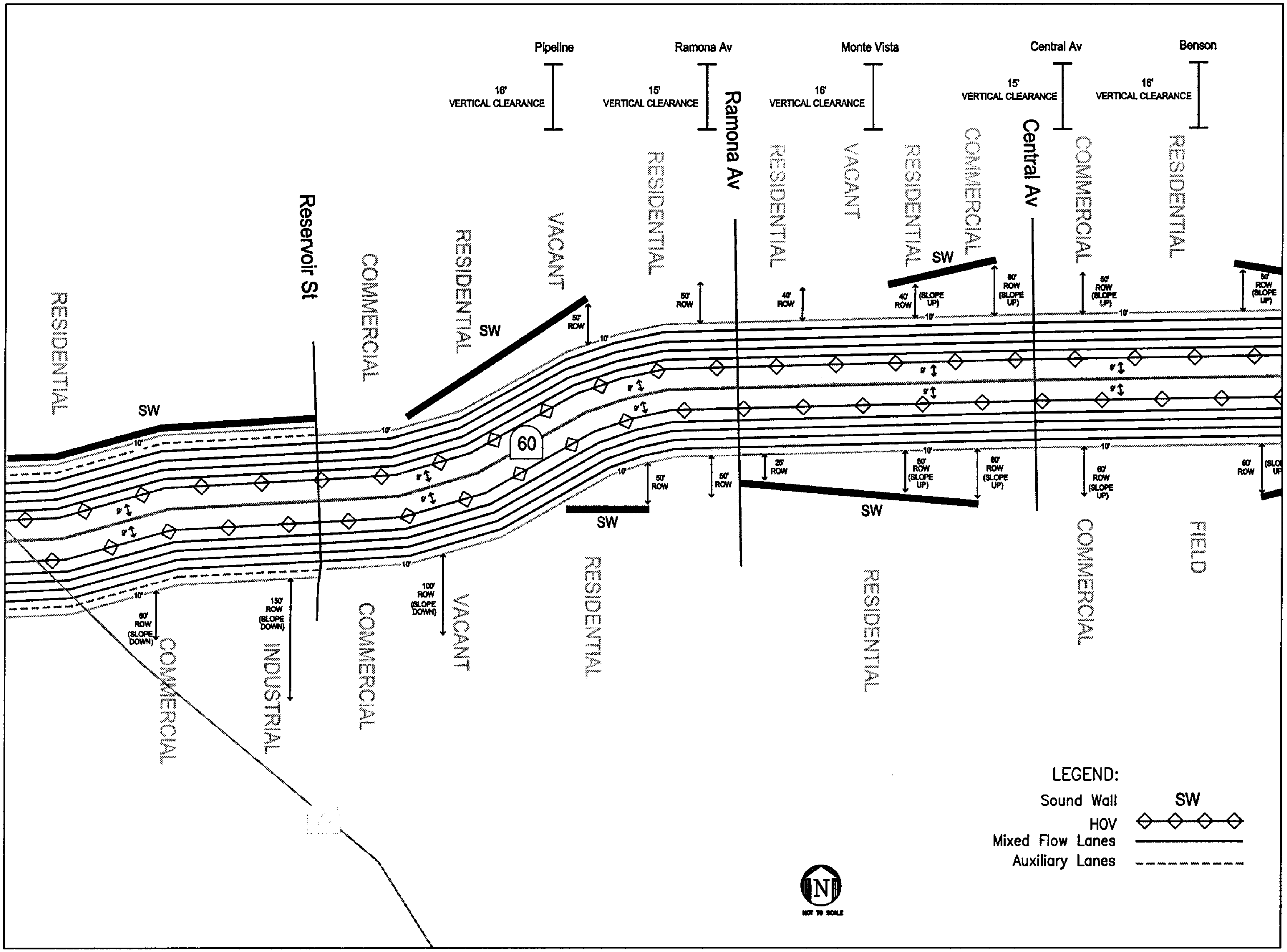


FIGURE 3.3-H
SR-60 PHYSICAL CHARACTERISTICS

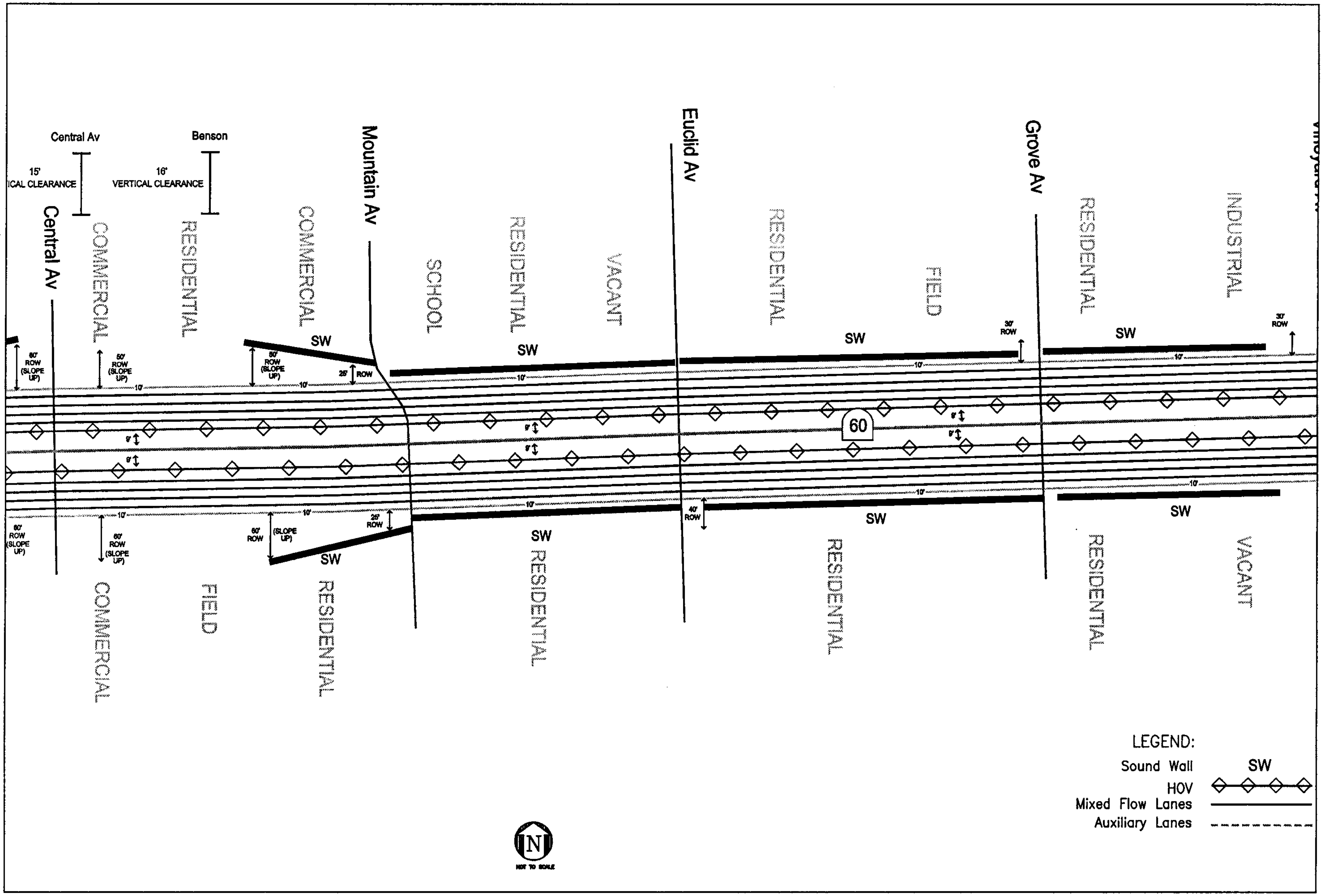


FIGURE 3.3-I
SR-60 PHYSICAL CHARACTERISTICS

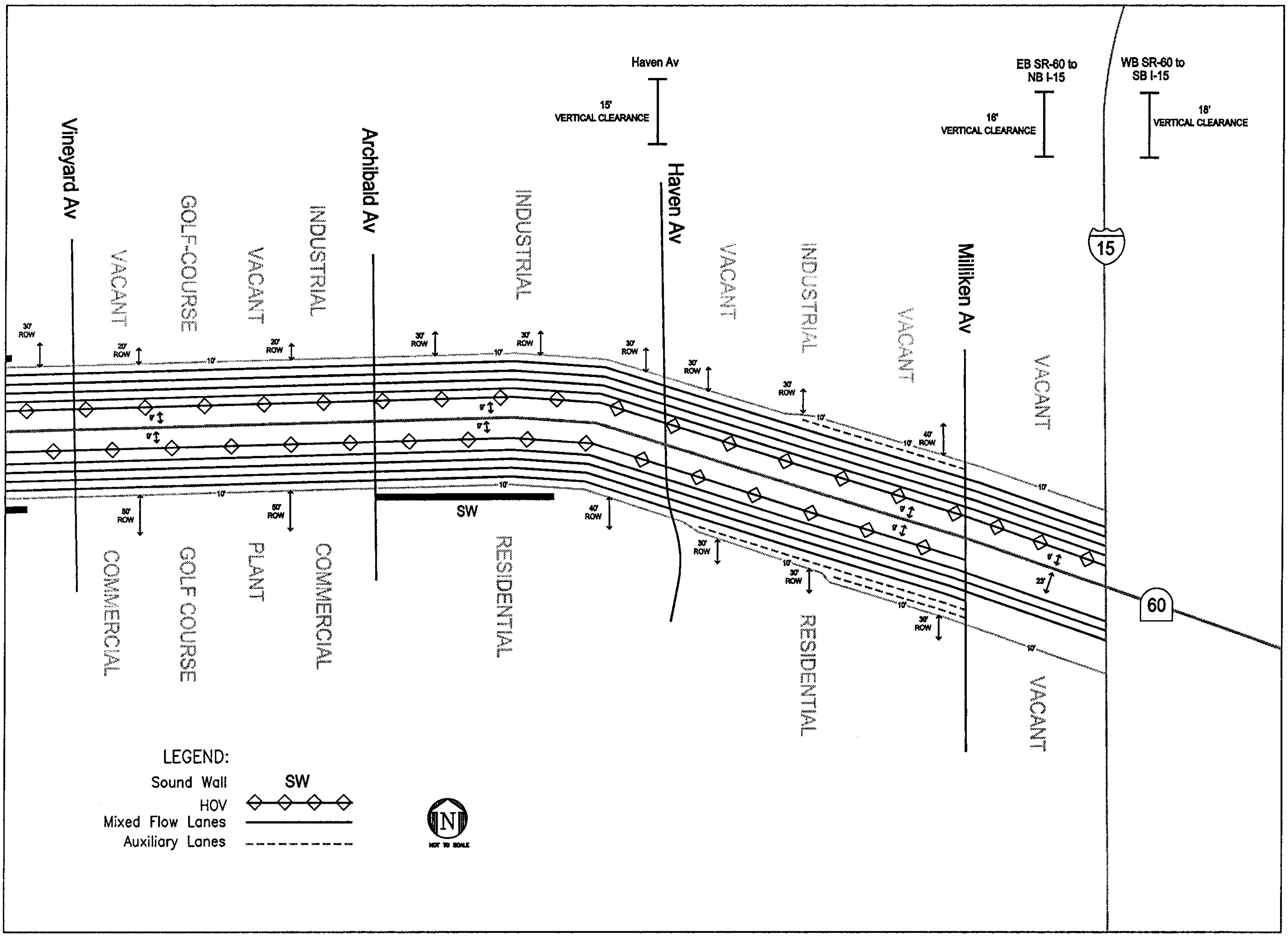


FIGURE 3.3-J
SR-60 PHYSICAL CHARACTERISTICS

III. OPERATIONAL CHARACTERISTICS

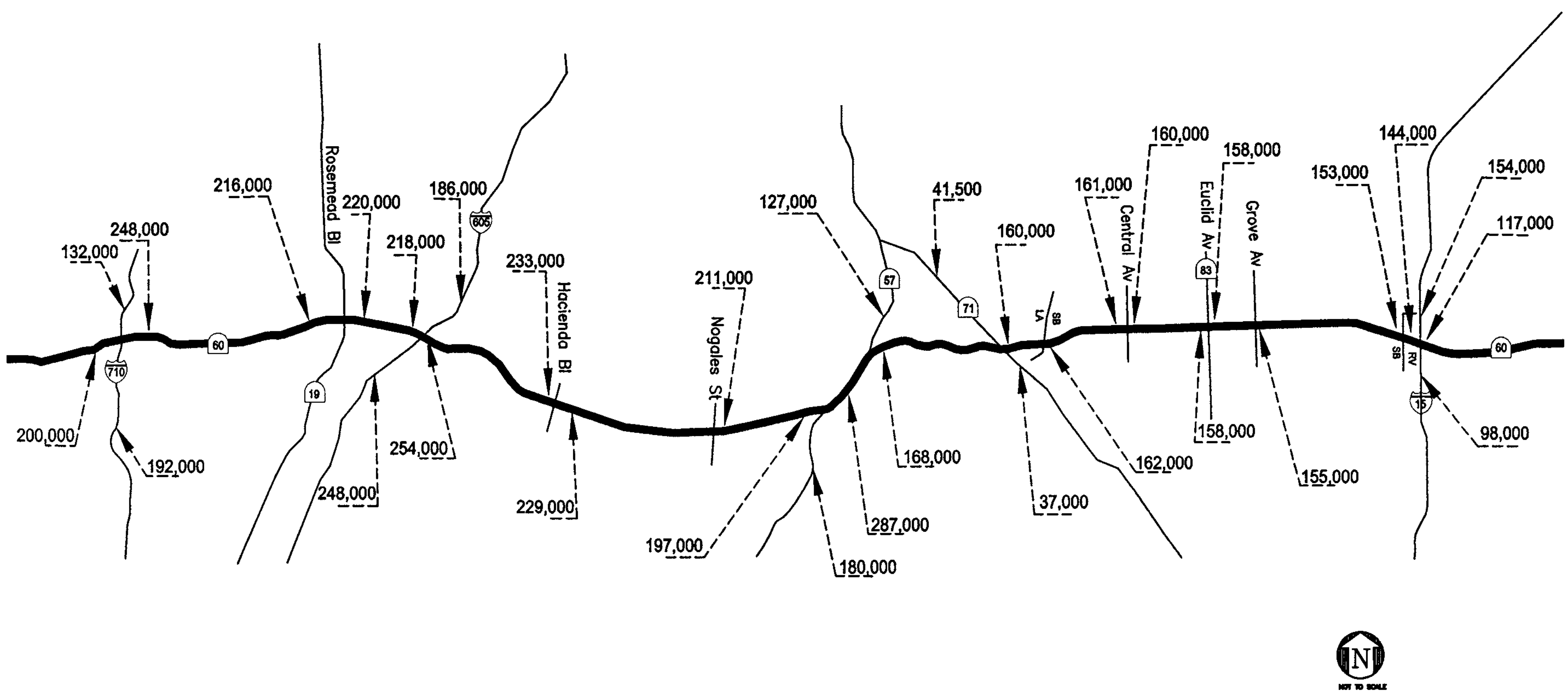
The operational characteristics of the SR-60 corridor were assessed in order to describe the ways it is used for (primarily) goods and passenger movement. These characteristics provide the "yardstick" by which the user measures (or compares) the quality or level of service provided by the corridor for both goods and passenger movement. The operational characteristics reviewed and evaluated for the feasibility study included:

- truck lane restrictions;
- average daily traffic (ADT);
- average daily truck traffic;
- traffic mix; and
- truck origin and destination patterns.

The State of California restricts all heavy trucks to the two rightmost lanes of all major roadway facilities such as freeways and expressways. The SR-60 corridor does not have any additional restrictions for heavy-duty truck movements.

Figures 4 and 5 show the average daily traffic (ADT) and the peak hour traffic on the SR-60 corridor for 1997. These volumes were obtained from Caltrans' *1997 Traffic Volumes on California State Highways.*

Figures 6 and 7 show the average daily truck volume and the truck percentages as part of the total traffic. As noted earlier in this report, trucks with 3 or more axles were included in these calculations since those are considered "Heavy Duty Trucks". These data were obtained from Caltrans, and in particular, the *1997 Annual Average Daily Truck Traffic on the California State Highway System.* The data was adjusted to reflect balanced daily average volumes and was also validated using observed truck traffic data collected by the San Gabriel Valley Council of Governments (SGVCOG) in support of the San Gabriel Valley Goods Movement Study as well as additional, observed truck counts collected at five locations in the SR-60 corridor as part of the current study. Please note that copies of the truck counts and the San Gabriel Valley COG data will be provided upon request.



KAKU ASSOCIATES

FIGURE 3.4
TOTAL AVERAGE DAILY TRAFFIC - 2 WAY

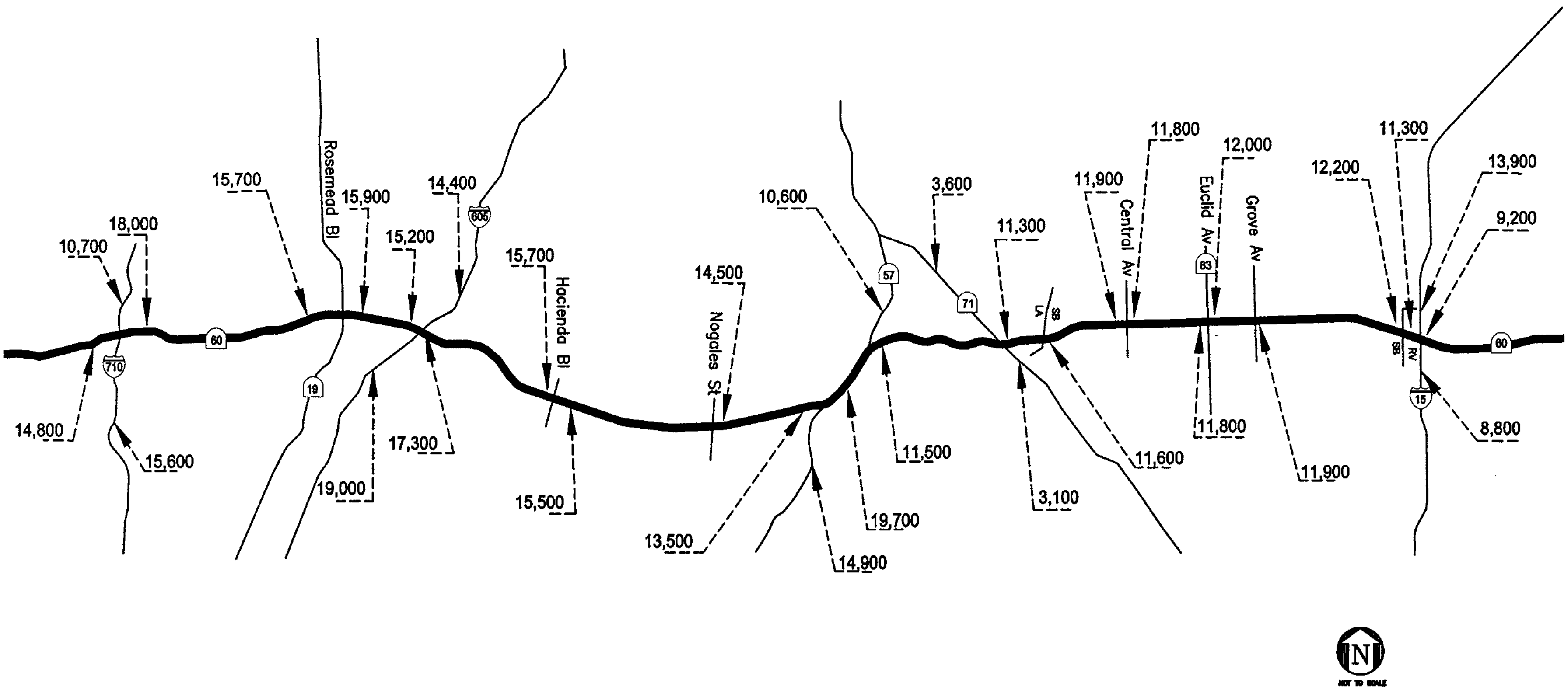


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FIGURE 3.5

TOTAL AVERAGE PEAK HOUR TRAFFIC - 2 WAY

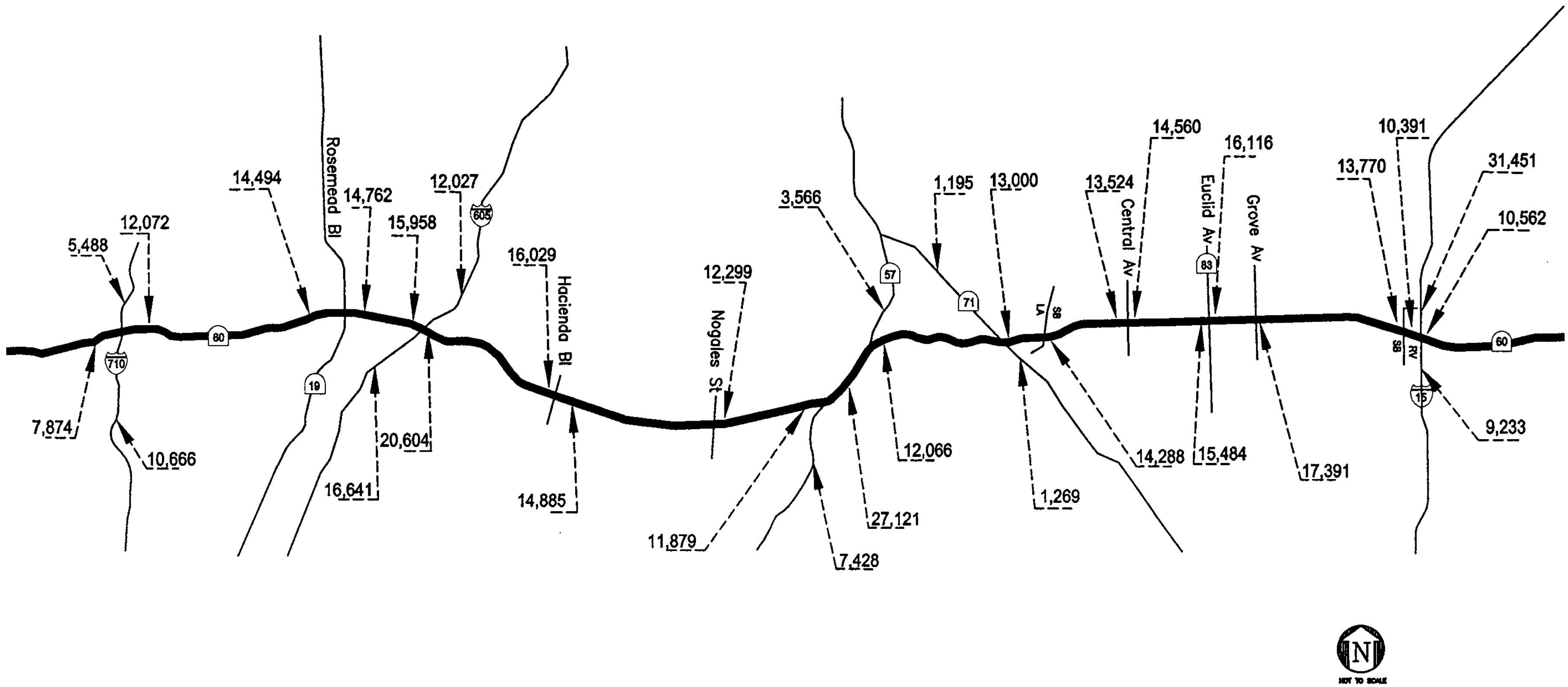

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Figure 3.6

3 + AXLE TRUCK AVERAGE DAILY TRAFFIC - 2 WAY
NUMBER OF TOTAL VEHICLES

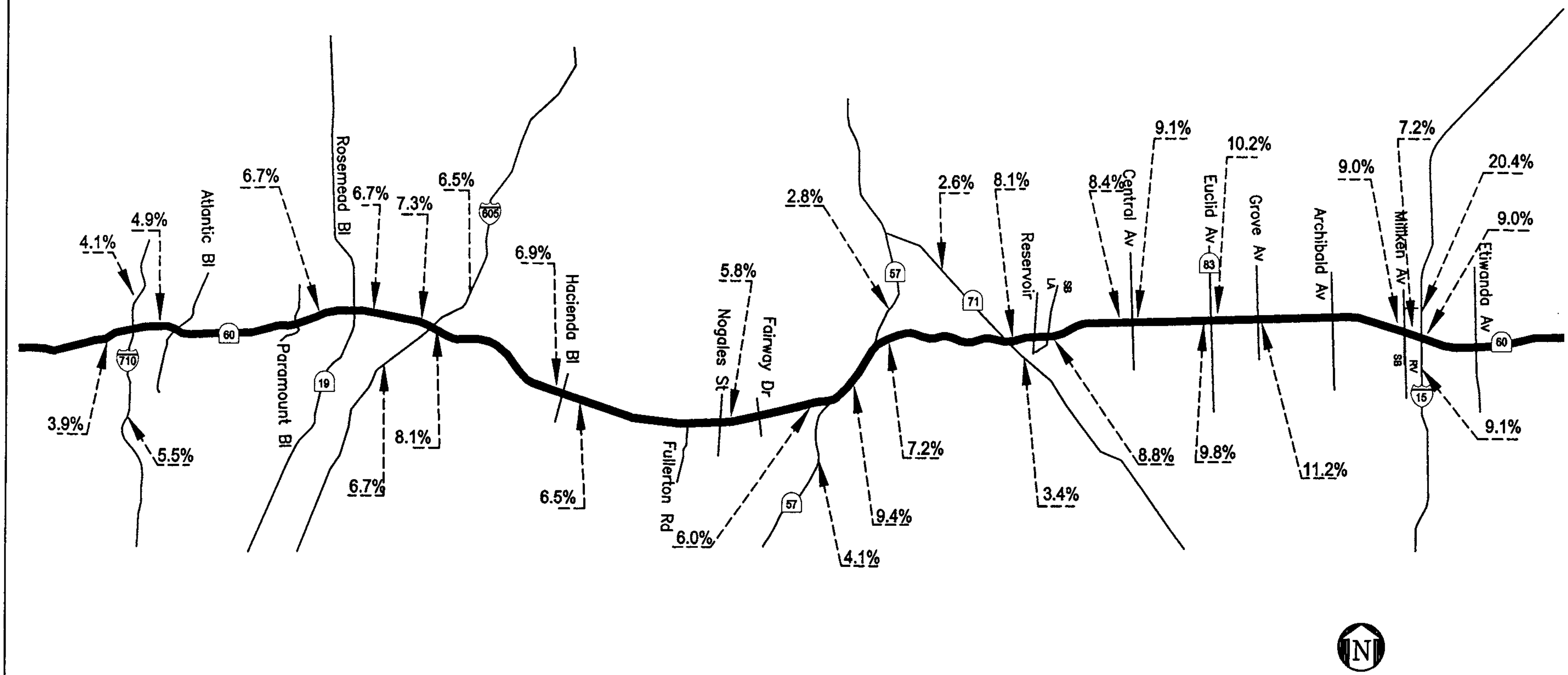

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Figure 3.7

3 + AXLE TRUCK ANNUAL AVERAGE DAILY TRAFFIC - 2 WAY
PERCENTAGE OF TOTAL VEHICLES

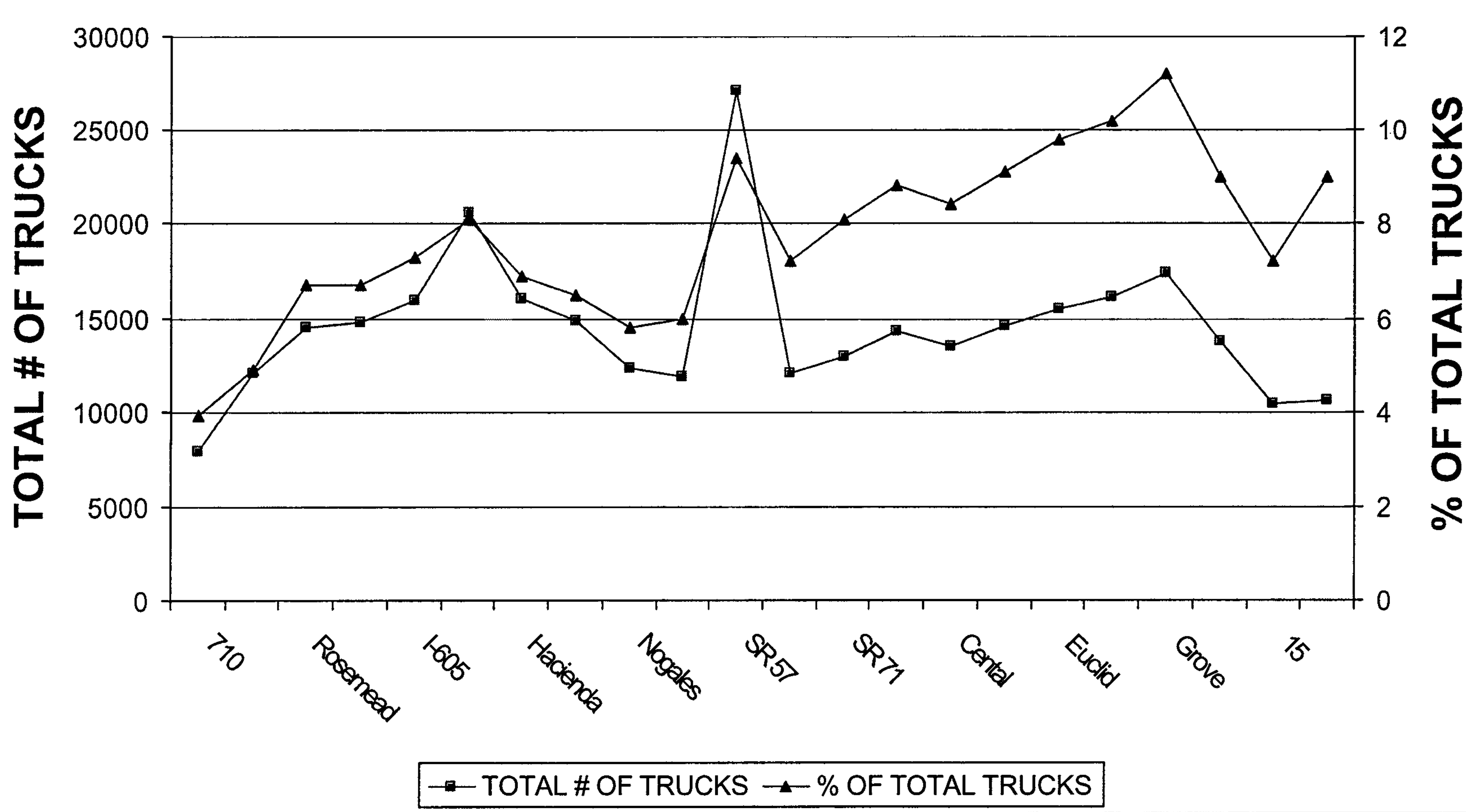
Figure 8 converts the information on Figures 6 and 7 into a profile of truck volumes on SR-60. The profile tracks the total number of trucks on the freeway and the percentage of all traffic represented by those trucks. Peaks in number of trucks are reached around the I-605 interchange (over 20,000 trucks per day), on the SR-60/SR-57 common section (more than 27,000 trucks per day) and in the vicinity of Ontario Airport (17,400 trucks per day). The percentage of all traffic that is trucks reaches high points near I-605 (8.1%) and in the SR-60/SR-57 section (9.4%) but east of Central Avenue the percentage climbs higher than either of those points to a corridor-peak of 11.2% near Ontario Airport. For the overall corridor, the peak number of trucks (31,400 per day) and percentage (20.4% of all traffic) occurs on I-15 just north of SR-60.

Figure 9 illustrates the truck origin and destination patterns on the SR-60 corridor. Truck origin and destination travel patterns were developed using the Caltrans traffic count data identified above in addition to the commodity flow data from the Caltrans Intermodal Transportation Management System (ITMS). The results of Figure 9 show that:

- approximately 5% of the trucks using the SR-60 either enter or exit the SR-60 corridor west of I-710;
- 13% of the trucks arrive at SR-60 via I-710, including 9% from/to the south and 4% from/to the north;
- I-605 contributes 13% to the SR-60 truck volume including 7% from/to the south and 6% from/to the north;
- Roughly 6% of the trucks on the SR-60 enter or exit using the SR-57 including 4% to/from the south and 2% to/from the north;
- I-15 to the north of the SR-60 is the major contributor to the total truck traffic on the study corridor, carrying 54% of all heavy duty truck traffic;
- I-15 to the south carries 6% of the trucks using the corridor; and
- approximately 3% of the truck traffic on the SR-60 corridor travel on the SR-60 east of the I-15.

As stated earlier in this section, the data to develop the truck patterns on the corridor was obtained using the Caltrans ITMS commodity flow data and heavy duty truck traffic counts collected from Caltrans and other local agencies within the SR-60 corridor. In the fall of 1999, this information will be adjusted and refined using the detailed results of the SCAG Heavy Duty Truck Model. In addition, recent travel characteristic data collected by the California Air Resources

FIGURE 3.8
PROFILE OF TRUCK VOLUMES ON SR-60



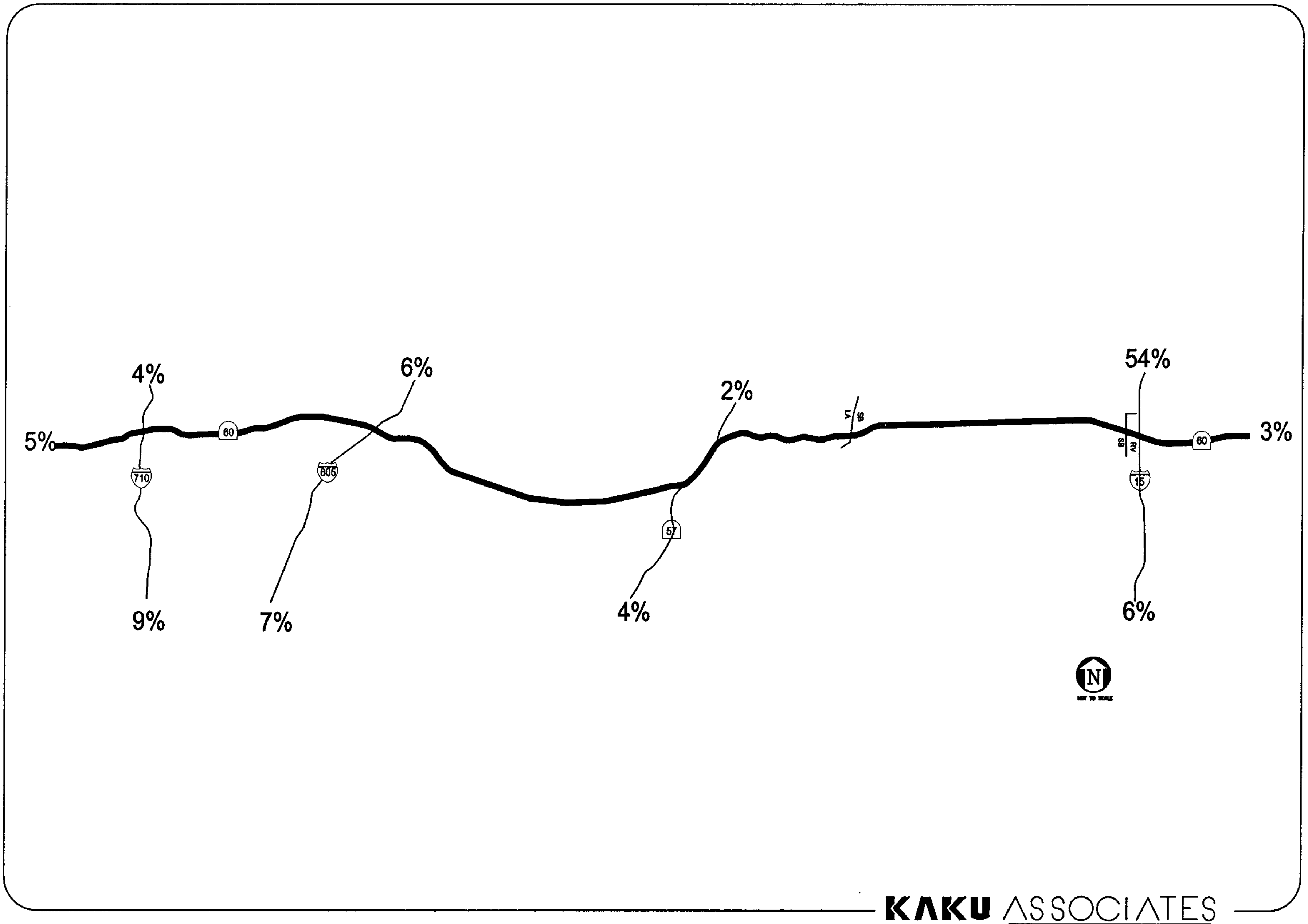


Figure 3.9
RELATIVE INFLUENCE OF TRIBUTARY/FEEDER HIGHWAYS AND SEGMENTS
ON SR-60 TRUCK VOLUMES

Board (CARB) on heavy-duty truck activity in California, including the SCAG metropolitan region, were evaluated. This data considered a limited sample of trucking companies and trucks surveyed using Global Positioning System (GPS) equipment. A small number of trucking companies in California agreed to participate in the project that included installing GPS equipment on a small portion of trucks within their fleets to identify daily movements, origins and destinations, and routes used by the vehicles. Therefore, this dataset is of limited value in the assessment of truck origins and destinations and truck impacts focusing on the SR 60 corridor. Other analytical tools, such as the SCAG Heavy Duty Truck Model (upon its completion), offer more robust data relevant to the analysis and feasibility of SR-60 Commercial Vehicle Lanes.

IV. SAFETY CHARACTERISTICS

The safety characteristics of SR-60 can be best described by the general accident history of the corridor. Detailed accident data for Los Angeles County contained in the California Highway Patrol's Statewide Integrated Traffic Records System (SWITRS) database from 1996 through 1998 was used to support the safety analysis for the SR-60 corridor. Additional information from the Incident Reporting System maintained by Caltrans for 1997 and 1998 was used to assess the accidents on SR-60 for San Bernardino and Riverside counties. These locally based safety databases were used as the foundation for the safety characteristics presented in this section. This analysis was conducted to identify the recent accident history of heavy-duty trucks on the corridor and to provide an assessment of the incident impacts associated with truck accidents. The safety characteristics reviewed and evaluated for the feasibility study included:

- number of total truck accidents; and
- number of truck accidents by type including property damage only, injury, and fatality

In addition, several national sources of accident information were reviewed and evaluated for potential use in supplementing the local data identified previously. These sources included the *California Urban Freeway Gridlock Study* prepared by Caltrans in 1988, the *Characteristics of Urban Freight Systems* conducted by the Federal Highway Administration in 1995, and *Intelligent Transportation System Deployment Analysis System* (IDAS) conducted by Cambridge Systematics in 1999.

Accident information obtained from the CHP SWITRS database included total number of trucks accidents on the SR-60 corridor in Los Angeles County, and number of accidents by property damage only (PDO), injury, and fatality categories. Information obtained from the CHP SWITRS database is kept on a time-sequence basis and enables assessment of the percentage of accidents in which heavy-duty trucks have been involved.

Table 1 shows the total number of truck accidents that occurred on SR-60 in Los Angeles County between I-710 and Route 57. The total number of truck accidents on SR-60 is presented for 1996, 1997, and 1998, including the split between PDO, injury, and fatality accidents. As shown in the data, the number of accidents was consistent from 1996 to 1998, with 399, 394, and 465 accidents by respective year. The number of injury and fatality accidents were also very consistent from 1996 to 1998 ranging from 86 to 91. The number of property damage only (PDO) accidents increased in 1998 from 394 to 399 PDO accidents in 1996 and 1997.

The SWITRS database identified the number and type of truck accidents for a 22.2-mile section on SR-60 in Los Angeles County. Table 2 shows the locally based accident rates for 1996, 1997, and 1998 on this section of SR-60. Rates consider the total number of truck accidents by estimated annual VMT for 1996, 1997, and 1998 and are also expressed per 100 million truck VMT. These rates were developed from the number and types of accidents reported for this section of SR-60 and the daily heavy-duty truck counts reported for SR-60 in Section III Operational Characteristics. Truck VMT for this section of SR-60 were annualized to be consistent with the annual number of type of accidents reported by the SWITRS database.

Average truck accident rates obtained from the Caltrans Urban Freeway Gridlock Study were also evaluated as shown in Table 2. These rates represent 1988 conditions as well as average urban freeway conditions for the major metropolitan areas of California including Los Angeles. As presented in Table 2, the accident rates reported by the Gridlock Study were significantly higher for average urban freeway conditions than those shown locally for the SR-60 Freeway in Los Angeles. For example, the Gridlock Study showed an average of 273 truck accidents per 100 million VMT while the locally based SWITRS database indicates that truck accident rates on SR-60 range from 25 to 29 per 100 million VMT. This can be explained by many variables including:

- The Urban Freeway Gridlock Study accident rates were based on aggregate freeway segment data for roadways throughout California, including urban corridors (I-880 in the San Francisco Bay Area) with higher truck activity levels than SR-60;
- The Urban Freeway Gridlock Study rates were developed in 1988 and do not represent current conditions on SR-60; and
- The SWITRS database contained recent, relevant accident data specific to and representative of SR-60 in Los Angeles County.

The accident data obtained from the Caltrans Incident Reporting System included total number of

Table 3.1
Number and Type of Truck Accidents in Los Angeles County on SR 60 from 1996 to 1998

Year of Accident	Property Damage Only	Injury Accident	Fatal Accident	Total Accidents
1996	313	84	2	399
1997	303	87	4	394
1998	377	87	1	465
Total	993	258	7	1,258

Source: California Highway Patrol SWITRS database.

Table 3.2
Annual Truck Accident Rates per 100 Million VMT in Los Angeles County on SR 60 from 1996 to 1998[1]

Year of Accident	SR 60 (Los Angeles County)	Urban Freeways in California[2]
1996	25	N/A
1997	25	N/A
1998	29	N/A
Average Rate	27	273

Notes:

1) Annual and average truck rates for SR 60 were based on CHP SWITRS database and Caltrans Truck Volumes for 1996, 1997, and 1998.
2) Average truck rates for urban freeways in California were based on California Urban Freeway Gridlock Study from 1988.

Sources:

- California Highway Patrol SWITRS database and Caltrans.
- Perkins, David B. *Urban Freeway Gridlock Study: Technical Memorandum 1-4.* Prepared for California Department of Transportation. Cambridge Systematics, Inc., Cambridge, Massachusetts, November 1988, Table 2.

accidents for SR-60 in San Bernardino County over a two year period from 1997 to 1998. The number of accidents reported in this database for San Bernardino County on SR-60 were comparable to those in the SWITRS database for Los Angeles County. For example, the total number of truck-involved accidents on SR-60 in San Bernardino County totaled 319 accidents in 1997/1998 compared to 465 in Los Angeles County (as reported by SWITRS) in 1998. If divided by two, the two-year total of 319 heavy-duty truck accidents occuring in San Bernardino County would be approximately 160 accidents per year. This annual total of heavy-duty truck accidents would be consistent with the level of vehicle miles of travel in San Bernardino County compared to Los Angeles County. Table 3 shows the number of truck accidents occuring in San Bernardino County during 1997 and 1998.

As with the truck origin and destination travel pattern data presented in the Operational Characteristics section, this accident data will be refined as additional local accident data is obtained from other databases. The general relationships of heavy-duty truck rates and accidents will likely not change significantly.

TABLE 3.3
ANNUAL SR-60 TRUCK ACCIDENTS BY VEHICLE TYPE IN SAN BERNARDINO COUNTY ON SR-60 FOR 1997 AND 1998

Vehicle Type	Number of Accidents	Percentage of Truck Accidents
Truck/Truck Trailer	88	27.6%
Truck/Tractor & 1 Trailer	213	66.8%
Truck/Tractor & 2 Trailers	15	4.7%
Truck/Tractor & 3 Trailers	0	0.0%
Single Unit Tanker	0	0.0%
Truck/Tractor & 1 Tank Trailer	3	0.9%
Truck/Tractor & 2 Tank Trailers	0	0.0%
Total	319	100.0%

Source: Caltrans

V. ECONOMIC CHARACTERISTICS

The following economic studies to assess the potential impact of recent or projected future economic shocks on the feasibility of truck lanes on the SR-60 were reviewed:

- San Gabriel Valley Truck Study: Economic Analysis of Trucking Activity. Cambridge Systematics, Inc., Draft released to the SGVCOG Truck Task Force on September 9, 1999;
- San Gabriel Valley Industry Cluster Study, Applied Development Economics, June 1998;
- San Gabriel Valley Truck Transportation Study: Trends in the Ports of Long Beach/Los Angeles and Effects, JGP & Associates, March 8, 1999;
- LACMTA Economic Impacts of the Long Range Transportation Plan, Cambridge Systematics, Inc. June 1999;
- SCAG: Interregional Goods Movement Study. Tioga Group. Covers regional goods movement infrastructure, commodity movements, forecasts, and potential future developments;
- "SELAC" Gateway Cities Trucking Study. Meyer, Mohaddes Associates and The Tioga Group. This study analyzed trucking infrastructure, operating issues, and economic impact for the 28 Gateway Cities; and
- Los Angeles/Long Beach Long-Term Cargo Forecast – Tioga Group and Mercer Management Consulting. The forecast projects long-term cargo trends, intermodal traffic forecasts, and competitive assessments of port market shares.

As a result of this review, a more complete understanding of regional, national and international trends in goods movements along the SR-60 corridor has been acquired. In addition, on-going review of current economic literature and periodicals has been maintained. These are especially helpful in gauging the strength and pace of the emerging recovery in Asia and its impact on commodity flows along the SR-60 corridor. This knowledge will be used to verify the forecasts of truck volumes from the SCAG Heavy Duty Truck Model and help establish ranges for sensitivity analysis of the financial scenarios.

Export Based Truck Movements

A considerable amount of local data available of export-based truck movements will be assembled. This analysis will be based primarily on the truck origin and destination results obtained from the SCAG Heavy Duty Truck Model. Upon its availability, SCAG Heavy Duty Truck Model external-to-external truck movement outputs to and from the SCAG metropolitan region will be used for this analysis. Port of Long Beach and Port of Los Angeles related truck movements impacting the SR-60 corridor from the SCAG Heavy Duty Truck Model will also be used to support this analysis. Truck movement data by vehicle type – light heavy, medium heavy, and heavy-duty trucks – will also be evaluated.

Regional Economic Models

Cambridge Systematics has been working with the LACMTA on an analysis of the economic impacts of the Authority's Long Range Regional Transportation Plan (RTP). The effects were analyzed using the REMI modeling system, developed by Regional Economic Models, Inc. The results of this modeling were then used to conduct a benefit-cost analysis that included not only the direct user benefits of the RTP, but also added benefits that result because business becomes more competitive. These economic benefits consist of gains in employment and increases in output or value-added by businesses located in Los Angeles County. In order to convert new jobs into a monetary measurement, the benefit-cost analysis uses the net change (i.e., the increase) in personal income. The use of net change in personal income also avoids double counting economic benefits.[1]

[1] Economic impact analysis may be used to determine the net benefits of collecting tolls and/ or raising taxes to fund the construction of commercial vehicle lanes. Furthermore, the economic modeling will estimate the net change in personal income due to the SR-60 Truck Lanes. This stream of net changes in personal income may be added to the project's direct user benefits and estimated expenditures to calculate a benefit cost ratio.

The Kaku Associates team did not propose using an economic model in the feasibility analysis of the SR-60 truck lanes.[2] (While such a tool provides many insights and would be useful if SCAG elected to conduct a benefit-cost analysis of truck lanes on SR-60, benefit-cost analysis would logically follow this study only if the financial feasibility analysis indicated that the project could be financed with a reasonable mix of tolls and public funding. The economic impact analysis is an integral part of the benefit cost analysis and distinct from a financial feasibility analysis. Furthermore, conducting an economic impact analysis in this study would detract from the primary effort and will not contribute to a determination of financial feasibility.

[2] The LACMTA REMI model would probably not be available to SCAG due to the software licensing provisions and if so would only cover one of the five SCAG counties. A five-county REMI model could be purchased by SCAG and used to model economic impacts of SR-60 and the other truck lanes. A more complete overview of the REMI is provided in the article: "Policy Analysis Applications of REMI Economic Forecasting and Simulation Models," *International Journal of Public Administration, v.18, n.1, pp.13-42, 1995.*

VI. CONCLUSIONS AND COMMENTS

The data obtained on the SR-60 corridor will be analyzed in Task 4 to characterize physical improvement opportunities and operational and safety constraints. The physical data shapes the various design configurations appropriate for different segments of this particular freeway. The operational characteristics will aid in making decisions on the necessity of adding new truck lanes as well as on the capacity required of the new truck lanes. The safety characteristics of the SR-60 will be used in conjunction with the physical and operational characteristics in determining the need for separate lanes and their design.

Chapter 4
Existing Conditions

I. INTRODUCTION

The Task 4 Report documents the existing conditions in the SR-60 corridor. It analyzes its physical, operational and safety conditions to form the basis for the evaluation of conceptual alternative improvements in Task 5. The analysis performed in this report utilizes the data collected and documented in the Task 3 Report.

The physical conditions on the SR-60 were evaluated to characterize improvement opportunities in the corridor. These characteristics will provide the basis for the development of the conceptual alternative improvements. The operational conditions on the study corridor were analyzed to describe the existing quality or level of service provided by the corridor for both goods and passenger movement. These conditions will dictate which conceptual alternative improvements, developed at first based on the physical conditions, are relevant for this particular corridor. Finally, the safety conditions on the SR-60 corridor were assessed to determine the areas requiring improvement. The safety constraints will be used in conjunction with the physical and operational conditions to determine the need for separate lanes and their design.

II. PHYSICAL CHARACTERISTICS

The SR-60 between the I-710 and the I-15 is a very constrained urban corridor with few opportunities for improvements. Most of its center median has been utilized or will be utilized by the Year 2020 to accommodate HOV lanes while its shoulders either provide the required width or currently operate at substandard conditions. Consequently, all truck lane improvements will require freeway widening outside the existing paved roadway and may involve some right-of-way acquisition.

The constraints on horizontal expansion of the SR-60 corridor are illustrated in the existing right-of-way conditions documented in the Task 3 report. Nowhere in the corridor is there room to add even one lane in each direction within the existing paved section of roadway (i.e., in the median or shoulder). In fact, for 30 % of the corridor's length, adding a lane of capacity would require acquisition of new right of way on each side of the corridor. Adding two lanes in each direction would require new right of way for 50% of the corridor on the north side and for 60% of the corridor on the south side. Even adding an elevated structure in the freeway right of way would be possible within the existing paved section for only 40% of SR-60's length; for 60% of the length right of way currently owned by Caltrans would have to be paved to widen the freeway (for only 2% of the corridor length would new right of way be required).

As mentioned above, since the corridor is very constrained one possible strategy to avoid right of way acquisition involves placing the additional lanes on an aerial structure which only requires approximately 2 percent of new right of way for implementation. A key issue in the implementation of an aerial structure involves the freeway elevation in relation to the surrounding street system because intercepting streets' overcrossings dictate the aerial structure's height. A higher structure presents more issues such as higher costs and more visual intrusion. Fortunately, the study corridor is for the most part at a higher elevation than the surrounding street system (i.e., there are more undercrossings than overcrossings along the freeway). There are a total of 44 overcrossings along the SR-60 corridor ranging in vertical clearance from 14'10" to 75' (on the I-710 interchange). The majority of the overcrossings, however, have vertical clearances of either 15'-16' or 25'. The Task 3 report presents the location of each overcrossing along with its vertical clearance.

Another very important physical characteristic to consider when evaluating roadway performance, especially when a large volume of truck traffic is present, involves the roadway's grades. Steep grades greatly influence truck operations and consequently the vehicular movement as a whole on the facility. On the SR-60 there are only two locations where the freeway grade has an effect on traffic. The first one starts to climb in the eastbound direction approximately at Vail Street, peaks around Paramount Boulevard and San Gabriel Boulevard and descents to approximately Santa Anita Avenue. The second grade, which is a more pronounced grade, occurs through the Chino Hills area. It starts to climb in the vicinity of Diamond Bar Boulevard, peaks close to Phillips Ranch Road and descends to approximately the SR-71.

The three physical characteristics of the study corridor that primarily assist in the design of conceptual alternatives include horizontal constraints, vertical clearances and roadway grades. The SR-60 corridor contains only two significant grades between the I-710 and the I-15. It is a very constrained corridor providing few opportunities for widening improvements. Finally, it has some vertical clearances constraints (forty-four overcrossings) throughout its length ranging from 14'10" to 75'.

III. OPERATIONAL CHARACTERISTICS

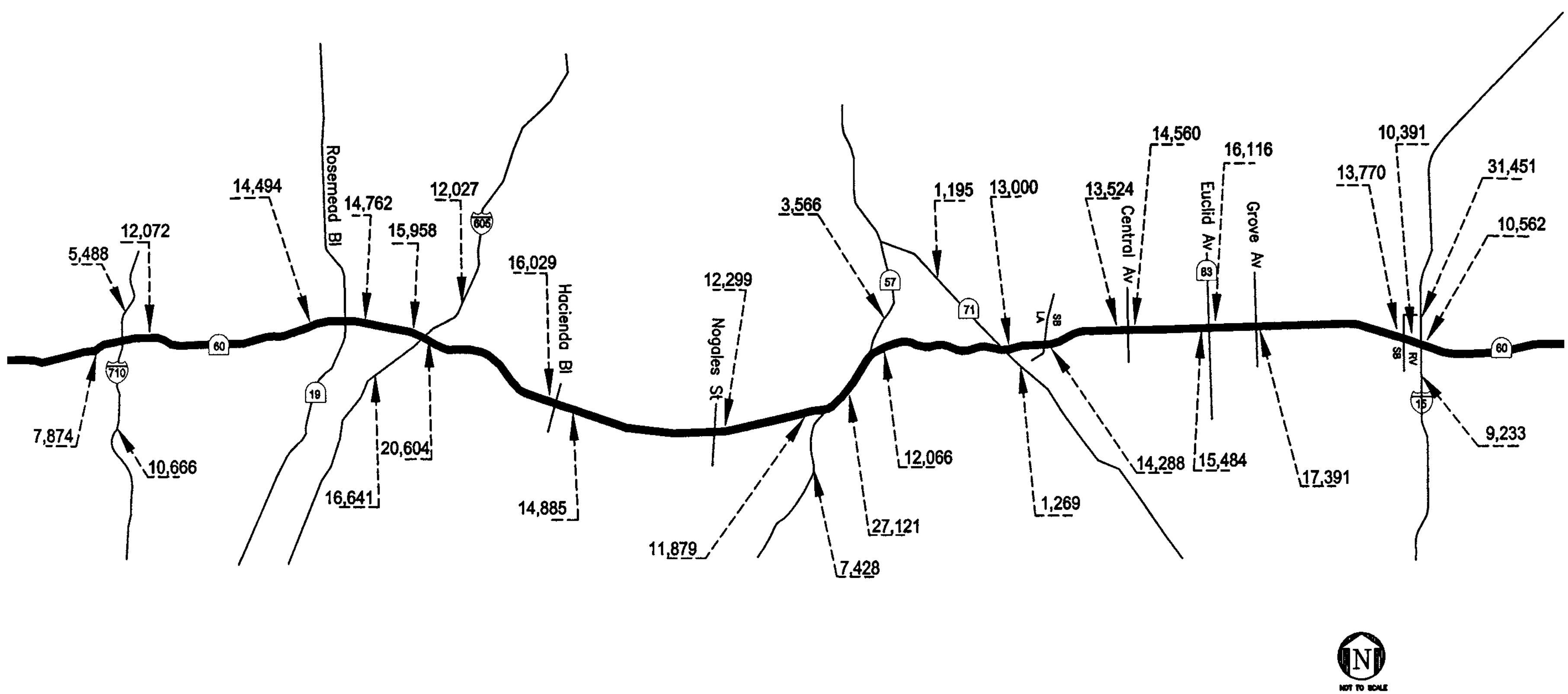
The operational characteristics of the SR-60 were evaluated to indicate the existing quality or level of service provided by the corridor for both goods and passenger movement. In order to evaluate existing conditions on the corridor, an extensive data collection effort was undertaken to develop a detailed current description of the corridor. The results of this effort include an inventory of the corridor's physical characteristics (discussed in the previous section), truck and total volumes on the corridor, truck patterns and traffic mix composition. The Task 3 report documents the data collection effort.

This section discusses in detail the truck volumes on the corridor, the existing level of service on sections of SR-60 and the existing truck patterns as well as expected changes in the truck patterns on the corridor due to issues such as the completion of the Alameda Corridor.

Truck Volumes

Figures 1 and 2 show the average daily truck volumes and the truck percentages as part of the total traffic obtained primarily from the *1997 Annual Average Daily Truck Traffic on the California State Highway System.* The methodology to develop these volumes is discussed in detail in the Task 3 report where it was mentioned that these volumes were validated using observed truck traffic data collected by the San Gabriel Valley Council of Governments (SGVCOG) in support of the San Gabriel Valley Goods Movement Study as well as observed truck counts collected at five locations in the SR-60 corridor.

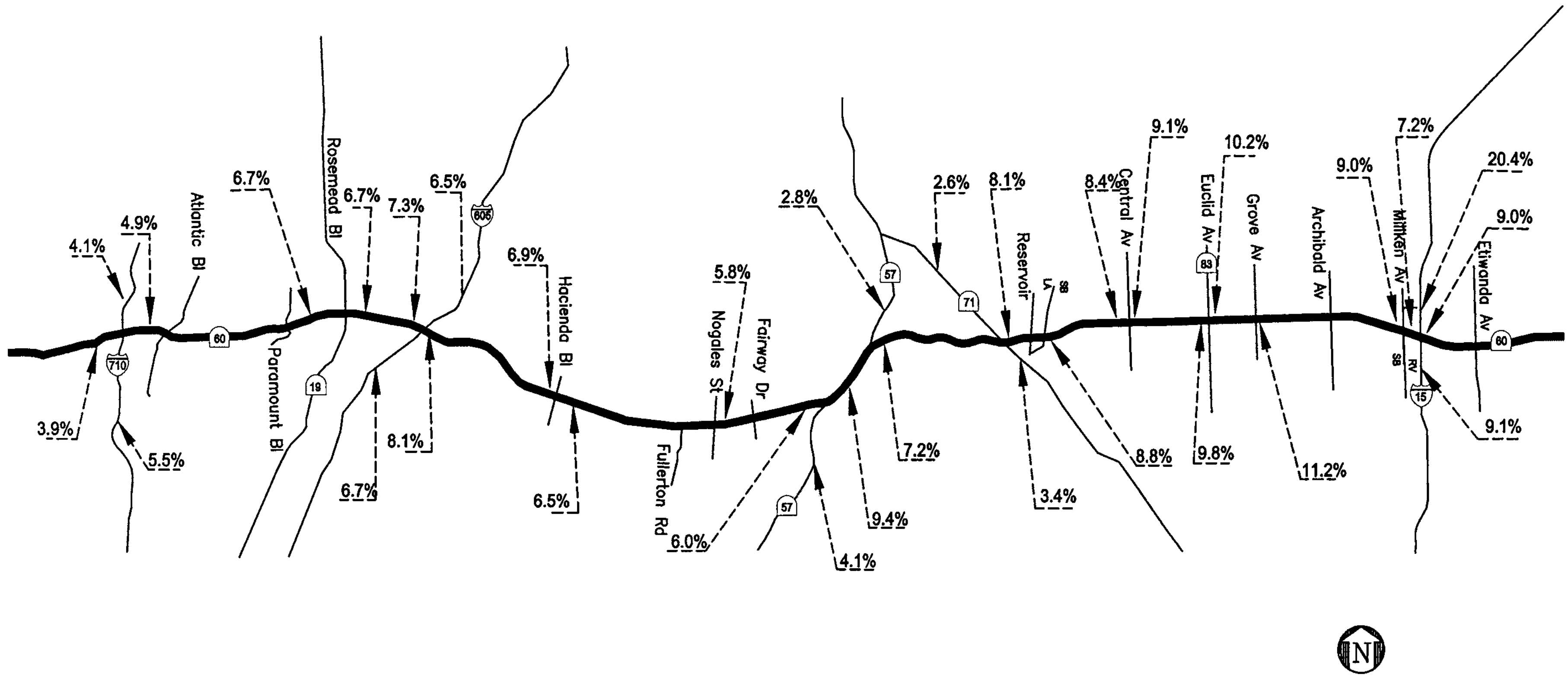
The July 1999 counts in the SR-60 corridor, besides providing data for validation, also provide information on the distribution of trucks throughout the daytime hours (6 AM to 7 PM). As can be seen in Figure 3, the five locations selected for the counts are at Mednik Avenue, Crossroads Parkway, Grand Avenue, Benson Avenue and Haven Avenue. The selection of these locations involved several aspects such as visibility opportunities (i.e., having a vantage point where the trucks could be counted), proximity to major facilities contributing to truck traffic on SR-60, and correspondence with available total 24-hour total traffic counts locations (for comparison



KAKU ASSOCIATES

Figure 4.1

3 + AXLE TRUCK AVERAGE DAILY TRAFFIC - 2 WAY
NUMBER OF TOTAL VEHICLES

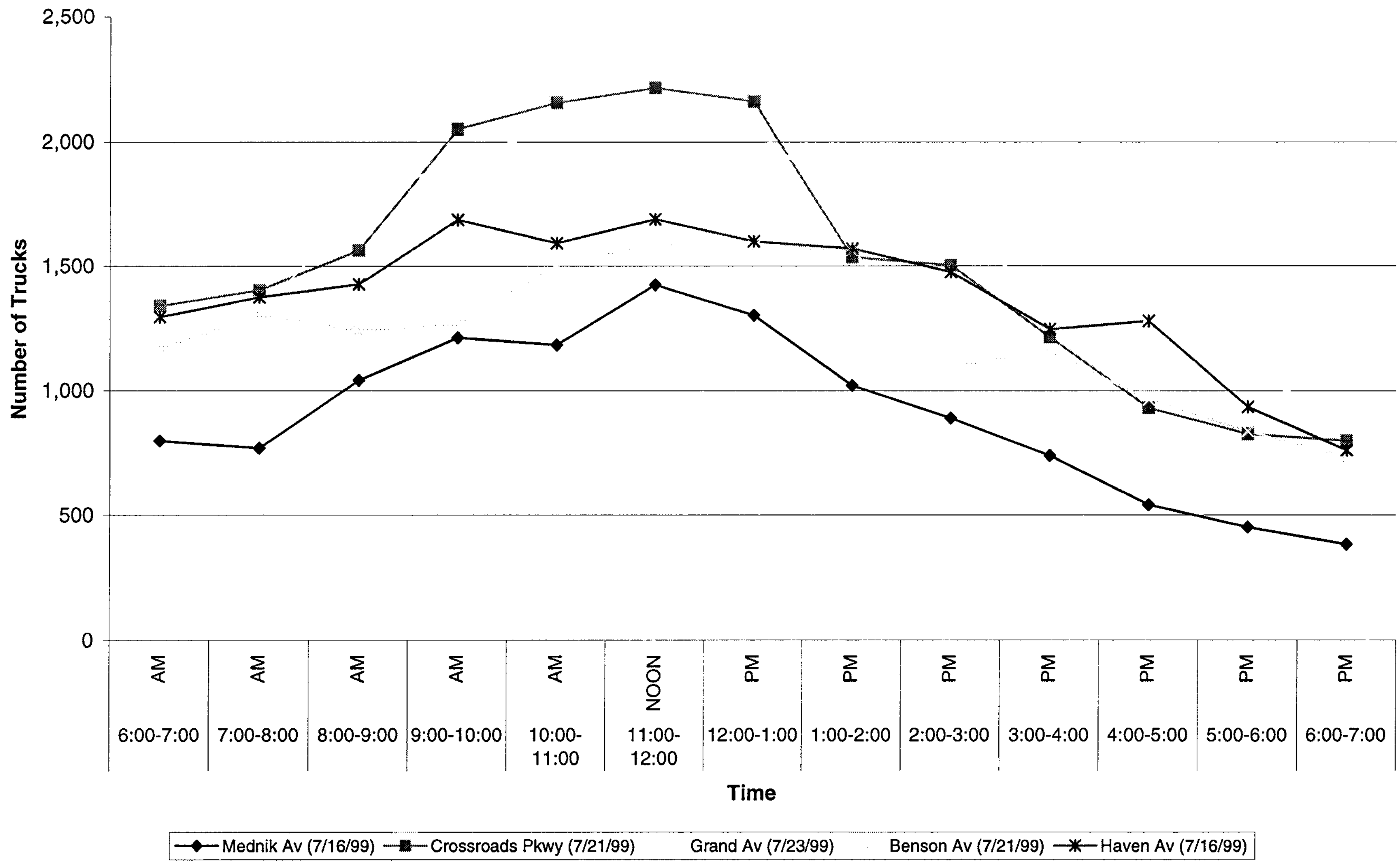


KAKU ASSOCIATES

Figure 4.2

3 + AXLE TRUCK ANNUAL AVERAGE DAILY TRAFFIC - 2 WAY
PERCENTAGE OF TOTAL VEHICLES

Figure 4.3
1999 Daily Truck Distribution



purposes).

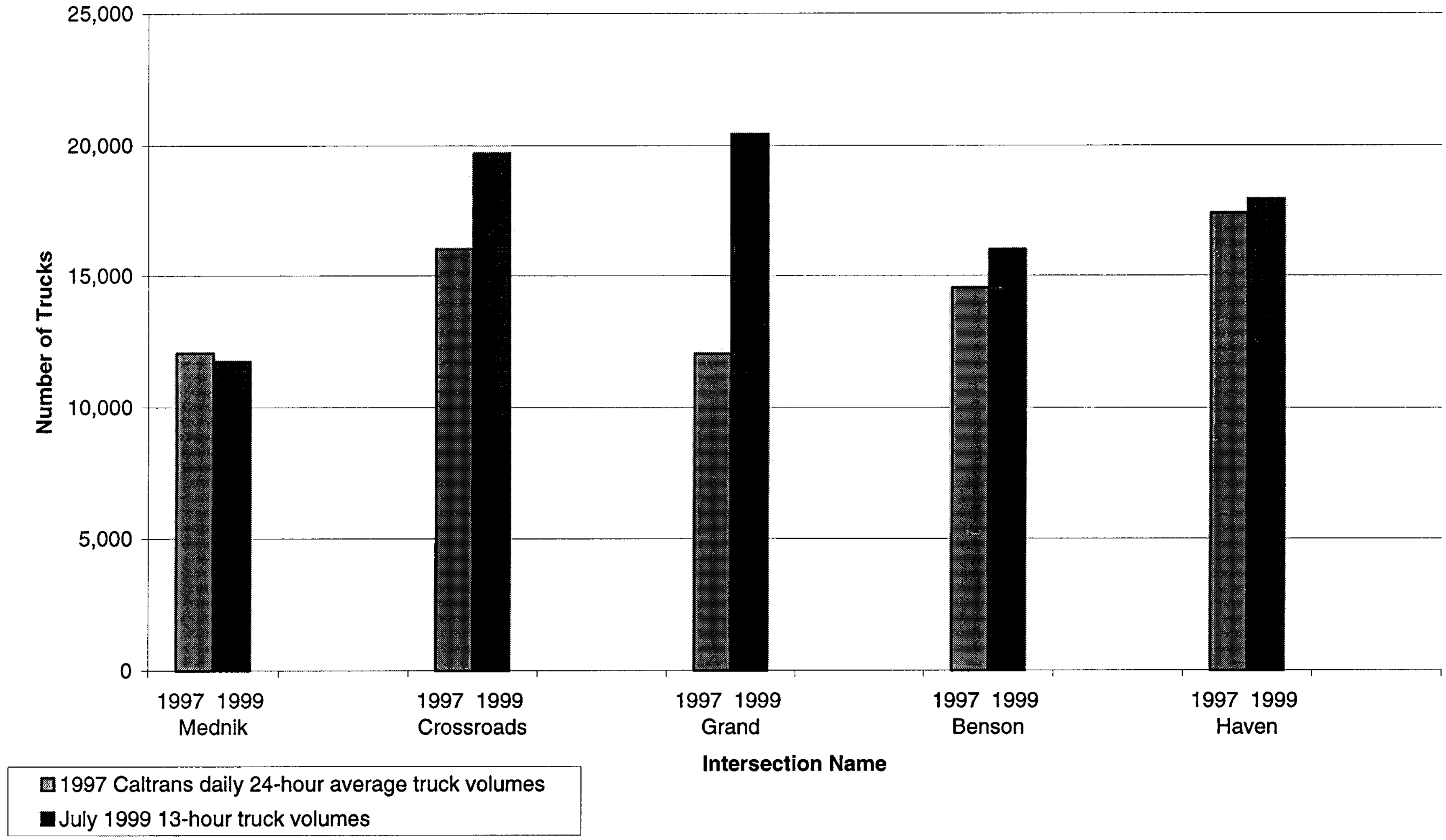
Figure 4 shows the 13-hour counts conducted in 1999 versus the average daily counts (24 hours) presented in the Caltrans *1997 Annual Average Daily Truck Traffic on the California State Highway System.* The comparison between the 1999 counts and the 1997 volumes range from approximately 3 percent lower at Mednik Avenue to approximately 70 percent higher at Grand Avenue. The fact that the 13-hour 1999 counts are higher than the average daily 1997 volumes illustrates the tremendous growth of corridor goods movement in only two years. This growth can be attributed in part to the booming economy and reinforces the need to address the issue of providing exclusive facilities for trucks.

Figure 3 also provides information on the trucks' peak hours. It can be seen that the truck peak is fairly dispersed throughout the day. The two-way volumes are highest between 9 AM and 2 PM. The eastbound peak west of the I-605 occurs around 11 AM while the westbound peak happens around noon. East of the I-605 the eastbound peak occurs around noon while the westbound peak happens around 10 AM. This change of peak times as well as the increase of total number of trucks east of the I-605 is consistent with the developed existing truck patterns which show that the I-605 is as significant a route for trucks entering the SR-60 (from both the north and the south) as the I-710 (see Figure 5).

The method used by Caltrans to evaluate a freeway's level of service involves assessing the average travel times and speeds in the facility. The Caltrans District Congestion Maps depict period of congestion, average travel times in minutes and average speeds in mph for most facilities in the region. The 1998 Congestion Map divides the SR-60 study corridor into three separate segments: from I-710 to I-605, from I-605 to SR-57 North and from SR-57 North to I-15. As can be seen in Table 1, the AM periods of congestion all fall within the 5:00 to 8:45 interval while the PM periods of congestion all occur between 15:15 and 19:45. The average travel times range from 14 and 32 minutes in the AM period and 7 and 23 minutes in the PM. Lastly, the average speeds vary between 22 and 34 mph in the morning and 28 and 43 mph in the afternoon. These average speeds and durations of congestion translate to the levels of service shown in Table 1.

In its "Route Concept Report" for SR60, Caltrans has identified level of service "F_0" as acceptable for all segments of the corridor. In 1998, all three segments of SR-60 were already experiencing levels of service worse than "F_0" ("F_2" and "F_3").

Figure 4.4
1997-1999 Truck Volume Comparisons



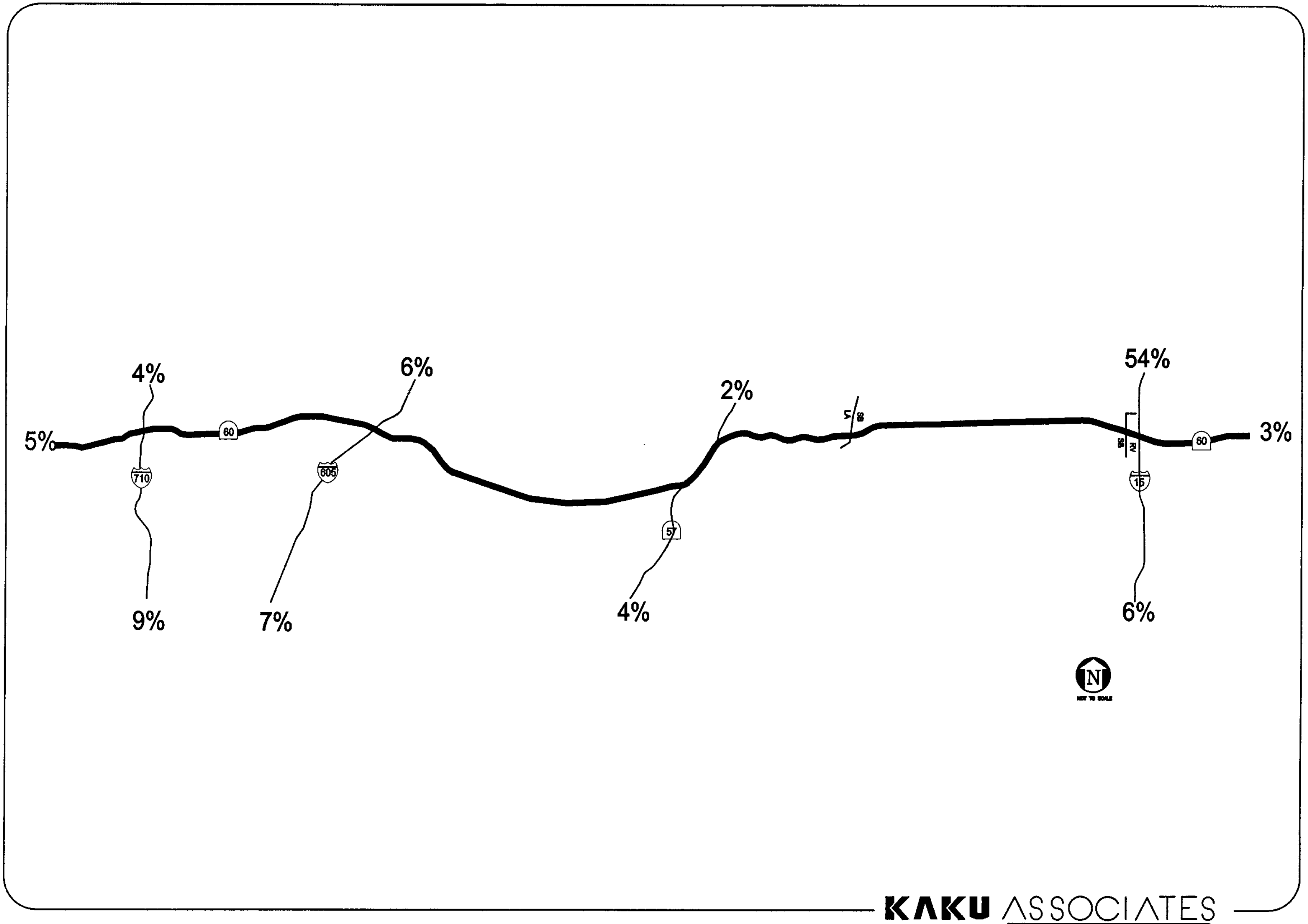


Figure 4.5
RELATIVE INFLUENCE OF TRIBUTARY/FEEDER HIGHWAYS AND SEGMENTS
ON SR-60 TRUCK VOLUMES

TABLE 4.1
EXISTING FREEWAY CONGESTION INDICATORS [a]

Segment	Distance (miles)	AM Period			Level of Service	PM Period			Level of Service
		Period of Congestion	Average Travel Time (minutes)	Average Speed (mph)		Period of Congestion	Average Travel Time (minutes)	Average Speed (mph)	
I-710 to I-605	8.5	6:30 to 8:45	15	34	F_2	15:45 to 19:15	18	28	F_2
I-605 to SR-57	12	6:15 to 8:45	32	22	F_3	15:15 to 19:45	23	31	F_2
SR-57 to I-15	16.5	5:00 to 8:45	14	26	F_2	16:00 to 18:00	7	43	E

Note:
[a] Source: Caltrans 1998 District Congestion Maps

IV. OTHER FACTORS AFFECTING EXISTING CONDITIONS

Truck Patterns

The existing patterns of truck movements along the SR-60 corridor have been identified and discussed in detail in the Task 3 report. These patterns are illustrated in Figure 5. Some recent events or on-going trends, however, can potentially cause certain future deviation in the truck volumes forecast to be present on the SR-60.

This section of the report focuses on the six major issues that could lead to the future deviation in truck patterns. They consist of the implementation of the Alameda Corridor, the merger of the Union Pacific and Southern Pacific Railroads, the rebound of the Asian economies, the increase size of the vessels, the trends of just-in-time inventory control along the SR-60 corridor, and the construction/upgrade of the Route 210/30 Freeway. The likely impacts of each are discussed below.

Alameda Corridor

Currently, two opposing views of the long-term impacts of the Alameda Corridor on the volume of truck traffic exist. On one hand, the Alameda Corridor will increase the dockside efficiency of the two ports, which has led to a wide spread perception that the increased efficiency will increase the flow of freight in and out of the Ports. Dockside efficiency is a critical competitive advantage. Truckers have singled out slow turnaround time as their biggest complaint about intermodal ports. For example, two trucking strikes in August (1999) at the Ports of Vancouver (BC) and Tacoma were precipitated by poor efficiency of the Ports' dockside operations. Many shipping companies had to redirect their vessels to other ports and both Ports (Vancouver and Tacoma) are concerned that some vessels may not return. An increase in the efficiency of dockside operations, therefore, should make the Ports of Los Angeles and Long Beach more competitive, thus capturing more freight from other west coast ports.

This perception is countered by the argument that freight flows are driven by economic activity and not by the capacity of goods movement infrastructure. Furthermore, current rail and truck mode shares are relatively fixed (i.e., inelastic), with each mode serving captured markets. The

Alameda Corridor will alleviate a severe congestion problem in the corridor and improve the drayage of containers into and out of the Ports. While these problems may only slightly limit the amount of truck traffic entering and leaving the Ports to date, it is possible that future growth in volumes could be constrained without the Alameda Corridor.

An imminent SCAG study will examine these issues in detail and report on the amount of freight that could be switched between rail and truck under a variety of interventions (both policy and infrastructure). This study should isolate the effects of Alameda Corridor on mode share and volumes.

Union Pacific-Southern Pacific Merger

The Union Pacific-Southern Pacific merger troubles have changed the dynamics of the trucking patterns into and out of the Ports of Los Angeles and Long Beach. Although the large amount of trucking and rail movements makes it difficult to detect the specific manifestations of the merger, some general patterns are expected. If the rail system is malfunctioning long-haul truck movements are required to compensate for the rail's absence. These trucks may inter-line with a "spoke" in a distribution chain (e.g. a less-than-truckload configuration) or may deliver to a customer directly—depending on the nature of the shipment. When the rail system is functioning properly, the trucking industry is more likely to have shorter moves in relation to "rail" shipments. Some indications of the merger impacts are presented below.

- It took three years for the Union Pacific's service to return to pre-merger levels, and it is still several years away from its promised level of service. (Journal of Commerce, "*Rail Merger Failures Out in the Open*", September 9, 1999).
- Estimates of the damages resulting from the merger range between $600 million and $1 billion. ("*Shipping Snarls Trade, Union Pacific Said Its Merger with Southern Pacific Would Cut Costs and Increase Efficiency. Instead It Precipitated a Crisis Expected to Last Through the Holiday Season*", Orange County Register, November, 27, 1997)
- Dow Chemical sued Union Pacific for $25 million to recover damages resulting from the post-merger gridlock. (March 18, 1998—DOW web-site.)
- Forestry and Chemical firms were hit especially hard as their budgets were "destroyed" by the need to transfer their products to more expensive trucks. (JOC, "*Rail Merger Failures Out in the Open*", September 21, 1999 and JOC—"*UP Merger Derails Shippers of Forest Products*", August 11, 1998.)

- Union Pacific system's failure resulted in a third of the container ships at the Ports of Los Angeles and Long Beach to be delayed approximately three to four days. A half dozen of these ships were redirected to Oakland, and there is fear that they will not be scheduled to return even after the crisis is over. ("*Shipping Snarl Trade: Union Pacific Said Its Merger with Southern Pacific Would Cut Costs and Increase Efficiency. Instead It Precipitated a Crisis Expected to Last Through the Holiday Season*", Orange County Register, November, 27, 1997)

- California companies like BASF and Home Depot were forced to put their merchandise on trucks. (Ibid.)

- Rail mergers have a wider impact on the economy than other industries. The service collapse of Union Pacific's acquisition of Southern Pacific affected coal-burning utilities, grain traders and exporters, manufacturers of all types, and rail users across the US." (JOC, "*Rail Merger Failures Out in the Open*", September 21, 1999)

The Union Pacific-Southern Pacific merger is expected to continue to create operating problems over the next three years, especially in Texas. The most persistent problems have been shortages of grain cars and boxcars while well cars, which carry containers, seem to be less affected. Since the vast majority of goods shipped through the Ports of Long Beach and Los Angeles are containers, the goods movements out of the Ports of Los Angeles and Long Beach are not as severely impacted as other sectors. Furthermore, the Ports expect rail and truck mode shares to become even less affected over the next few years.

Asian Economic Recovery

With the recovery of the Asian economies, the US Ports will be handling more outbound freight as American products are again in demand by Asian businesses and consumers. This should result in a more efficient truck/freight operation at the Ports. During the Asian recession, the American demand for goods remained high as our economy was rapidly growing. The result was a drastic imbalance of trade—where more freight was inbound than outbound. While some imbalance is a standard occurrence given the nature of the US trade with Asia, the problem was considerably worse during the Asian recession. For truck movements in and out of the Ports, the imbalance has caused trucks to arrive at the Ports empty solely to haul freight away from the Ports—a costly and inefficient move. Now that Asian demand is returning, over the long-term, the trucking operations should regain better balance as they haul freight to and from the Ports.

Increasing Vessel Size/Load-Centering

The increasing vessel size has led shipping companies to implement strategies known as "Load Centering".[1] As the vessels get larger and need to make fewer stops, ports will compete with one another to be one of the few ports of call. Ports that service these ships will succeed while those that do not risk seeing their traffic reduced dramatically. This trend will likely cause a concentration of trucks at a few "mega-ports" on each coast. The increased numbers of containers and trucks at these ports may tax the yard and gate facilities—a fact that will need to be addressed in order to remain competitive.

These mega-ships (i.e., Post-Panamax) require a channel depth of 50 feet when fully loaded. The Port of Oakland, one of the main west coast competitors for the Ports of Los Angeles and Long Beach, is currently dredging to only 40 feet, which prevents it from accommodating Post-Panamax ships. Furthermore, its less competitive rail connections and longer distance from Asian ports (in sea miles compared to Seattle and San Pedro) will make it less attractive as a port for these larger ships.

Increasing Just-In-Time Inventory Control by Businesses in the SR-60 Corridor

In general, just-in-time inventory control results in increased emphasis on the reliability of transporting raw materials, semi-finished products, and components to companies. It also has increased the need for the shipment of finished products to arrive when they are needed rather than to be stockpiled in warehouses in anticipation of future needs. Greater reliance on just-in-time strategy also results in the movement of a larger number of smaller sized shipments.[2]

These is no data currently available to assist in estimating the number of receivers or shippers located along the SR-60 corridor that may implement just-in-time inventory control over the next five or ten years. Nevertheless, it is reasonable to assume that a substantial proportion of the

[1] For example, the Regina Maersk is the largest container ship to visit the US. She is 318m long, 42.8m wide, has a draft of 14m and can carry 6,000 TEU. There were other slightly larger ships to come on-line totaling a fleet of approximately a dozen. Maersk currently has seven of these larger ships (Sally Maersk, Sine Maersk, Sofie Maersk, Soroe Maersk, Sovereign Maersk, Susan Maersk, and Svendborg Maersk). All of the ships (built between 1997 and 1999) are 347m long, 42.8m wide, has a draft of 14.5m, and can carry 6,600 TEU (New York Times, June 23, 1998).

[2] Cambridge Systematics, Inc., *Final Technical Memorandum: Strategic Plan for the Redevelopment of the Port of New York*, Task 1.2, page 25.

firms who have the potential to implement just-in-time control have already completed their transition. The remaining firms that still operate with a traditional distribution system will likely increase truck traffic in the Corridor when finally implementing just-in-time control because the number of vehicles required to accommodate such a strategy is greater. This increase, however, should be very modest compared to the volume of truck traffic moving in the corridor.

In general, trucking has a substantial impact on the economy of the San Gabriel Valley. About 31 percent of the Valley's jobs are in industries that are relatively dependent on trucking activity. While some of these trucking-intensive industries have been in steady decline since 1991, others have been growing and overall the Valley has seen an increase in trucking dependent jobs. As a whole, two trends in the San Gabriel Valley's industrial activity will likely have slightly greater - although still modest - effects on the volume of trucking along the SR-60 Corridor.

The industries of stone, clay and glass products; general merchandise stores; lumber and wood products; and paper and allied products ranked in the top half of industries by expenditure on trucking. These industries are on a declining trend in the San Gabriel Valley.

The most significant growth, over 4,300 new employees, and a 53 percent increase in payroll, has been in wholesale trade of durable and non-durable goods in eastern San Gabriel Valley.

In summary, as an overreaching assessment, we do not regard these events or trends as having a significant influence on the existing or future forecast trends. The one factor that may affect the conclusions of this study, which will be partly based on the future truck volumes forecast by the SCAG Heavy Duty Truck Model, is based on the fact that over the past decade the Ports of Los Angeles and Long Beach have consistently exceeded their forecasts of cargo.

Route 210/30 Freeway

A likely and expected impact of the construction/upgrade of the Route 210/30 Freeway involves the shifting of some traffic from the nearby freeways to the new freeway. Furthermore, most of the truck traffic traveling to and from the north of the state via I-210, which currently complete their journey eastward via I-10 or SR-60, is expected to remain on the new freeway until reaching I-15. This shift in truck traffic should create additional capacity on SR-60 which in turn would induce other traffic shifts around the area in a cascade effect.

In order to properly evaluate the effects of the Route 210/30 Freeway on the traffic composition and truck patterns on SR-60, a travel demand model should be utilized to simulate this condition. The SCAG Heavy Duty model will be used to analyze the effects of this Freeway as well as the effects of other programmed improvements and growth on SR-60's projected traffic. The results of this analysis will be provided in the Task 5 report.

V. SAFETY CHARACTERISTICS

The SR-60 corridor presents safety characteristics which are unique to this particular facility. The most crucial safety issue along the SR-60 involves the SR-60 and SR-57 merge, which requires a significant amount of weaving especially from trucks. Other safety issues include the difficulties for traffic to merge into SR-60 due to the large volume of trucks and the variability of speed between trucks and automobiles.

Several factors contribute to the difficulties truck traffic in particular face when trying to travel through the SR-60 and SR-57 merge segment. The key issue that makes this segment particularly complex, however, is the short distances provided for traffic weaving. This weaving is especially challenging for trucks since they require longer distances to perform these movements safely due to their size and operational characteristics. Forcing trucks to merge in inadequate distances increases the potential for accidents between trucks and automobiles.

California law requires trucks to stay in the two right lanes of all facilities. Moreover, the speed limit for trucks is 10 mph slower than the passenger vehicle speed limit. These two regulations combined create safety concerns when automobiles need to merge into the stream of traffic. The combination of lowering the speed limit for trucks and restricting the trucks to the right lanes increases the interaction between cars and trucks and therefore the potential for passenger car/truck crashes. Moreover, restricting trucks to the right lanes creates a "barrier effect" in merging areas. Besides the visibility problems trucks may create, they also intimidate many smaller vehicles' drivers. When combined with inadequate merging distances, prevailing in most urban freeways, these factors definitely pose safety issues.

Consequently, providing exclusive lanes for trucks would definitely improve the SR-60 corridor's safety. Exclusive lanes would minimize the interaction between trucks and passenger vehicles, diminish the merging difficulties and reduce the speed differential on the freeway. Furthermore, the exclusive lanes would be designed to alleviate the weaving conditions in the SR-60/SR-57 merged segment.

VI. CONCLUSIONS

The analysis of the physical, operational and safety conditions on the SR-60 corridor forms the basis for the evaluation of conceptual alternative improvements in Task 5. As mentioned previously these alternatives were developed taking into consideration the SR-60 particular characteristics.

Based on these characteristics, three main strategies seem sensible for this particular corridor: allowing trucks to share the HOV lanes at limited time periods, adding truck lanes to the freeway at grade and adding lanes above the freeway grade (on an aerial structure) for either trucks or cars. The HOV lane strategy was developed due to the very constrained nature of the corridor. Since approximately 80 percent of the study corridor will have HOV lanes by the year 2020, the amount of right-of-way acquisition (and consequently the cost) would be greatly reduced compared to the other alternatives. Furthermore, HOV lanes may be under utilized during off-peak periods providing unused capacity. The disadvantages of this alternative, however, may outweigh its advantages. It poses safety concerns due to the variability of speed between automobiles and trucks and blocked visibility. Operationally, it does not allow for passing opportunities or provide storage space for breakdowns. Finally, state law limits trucks to right lanes, and HOV lanes contain usage limitations due to funding sources.

The strategy for adding truck lanes at freeway grade was developed primarily due to the operational and safety conditions of the corridor. The complete separation of passenger cars and trucks would be ideal to minimize safety issues. Moreover, the addition of capacity to the freeway would improve its operations considerably. However, as discussed in Chapter II, a significant amount of right-of-way would have to be acquired for the implementation of this strategy. Besides the high cost associated with right-of-way acquisition, the environmental impacts caused by right-of-way acquisition may make this alternative unfeasible at portions of the corridor.

Finally, the strategy to add lanes above the freeway grade on an aerial structure was developed to combine the benefits of adding lanes for trucks and minimizing the right-of-way acquisition requirements where acquisition proves to be unfeasible. The disadvantages of this alternative include its high cost, aesthetic concerns and possible noise issues.

In order to adequately weigh the advantages and disadvantages of these alternatives, each alternative will be examined in detail and evaluated based on several criteria. These criteria include accessibility and mobility, cost-effectiveness, environmental sensitivity, safety impacts, operational characteristics, regulatory concerns and regional benefits. The results of this analysis will be presented in the Task 5 Report.